SCIENCE

VOL. 79 FRIDAY, MAY 25, 1934 No. 2056

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

A PROPOSED CLASSIFICATION OF THE CHEMICAL ELEMENTS WITH RESPECT TO THEIR FUNCTIONS IN PLANT NUTRITION

By the late Professor R. W. THATCHER

MASSACHUSETTS STATE COLLEGE

THE suggestion which is presented in this paper has two purposes in view: First, to systematize and perhaps to simplify the teaching of the subject of the mineral nutrition of plants; and second, to establish a systematic basis for investigations of the specific functions of the different chemical elements in plant nutrition, with special reference to those of the rarer elements discussed in a previous paper.[1]

There has been an immense amount of experimental study of the necessity for and specific functions of individual chemical elements in plant nutrition. The general result has been a rough classification of all the elements which have been found in plant tissues into two groups; the so-called "essential" and "non-essential" elements. The segregation of the elements into these two classes is based upon observed differences in the ability or failure of plants to thrive and reach normal maturity in the presence or absence of each particular element in the nutrient medium and atmospheric environment in which the plants are grown. On this basis, ten elements, namely, carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus, potassium, calcium, magnesium and iron, are usually listed as "essential," and all others as "non-essential."

As was pointed out in the paper just cited, however, it is now known that other elements are fully as "essential" to plant growth as are these ten; although their physiological function and the actual quantities required for adequate nutrition may be quite different from what is true of those previously included in that class.

Further, so far as the writer is aware, no attempt

[1] R. W. Thatcher, "Some New Aspects of Plant Nutrition," SCIENCE, 76: 1970, 281–285, 1932.

has been made to correlate the known or possible functions of the different elements in plant nutrition with their general chemical properties as functions of their atomic numbers and position in their systematic arrangement in the periodic table. The present proposal constitutes such an attempt.

Any such classification is, of course, subject to criticism as to terms used, assignment of individual border-line cases and validity of the fundamental thesis. Such criticism serves to establish the soundness or unsoundness of the proposal, and its value or futility as a basis for further study. It is to invite such criticism that this particular paper is presented.

Nearly all the chemical elements which are known, or have been suggested, to have any function in plant nutrition are included in the first four orbits of the periodic table. Their places in this table are as follows:

Group	I	II	III	IV	V	VI	VII	VIII
Orbit 1 ...	H	–	–	–	–	–	–	–
2 ...	Li	Be	B	C	N	O	F	–
3 ...	Na	Mg	Al	Si	P	S	Cl	–
4 ...	K	Ca	Sc	Ti	V	Cr	Mn	Fe Co Ni Cu
	(Cu)	Zn	Ga	Ge	As	Se	Br	–

It will be assumed that the reader is familiar with the use of these symbols to represent the names of the corresponding elements and with the general chemical properties of valence, ionic charges, etc., which accompany a particular place in the periodic table.

It is admitted at the outset that the following discussions apply in general only to the green, chlorophyll-containing types of plants and that many exceptions to the statements of fact and of theories here presented are to be found in the nutrition and metabolism of the fungi and other non-chlorophyll containing plant organisms. It is proposed later to make a similar study of the mineral nutrition phenomena of those types of plants whose energy requirements are derived from chemo-synthesis reactions, but for the present the discussion is confined to those plants whose nutrition begins with photosynthetic reactions.

Also, it is recognized that during the seed-germination and embryo development stage, before chlorophyll production begins, and in the seed-development and maturation stages of the higher plants, many reactions take place in which the functions of the several elements which are under discussion may be quite different from those ascribed to them in this classification. In fact, this is substantially a study of the relation of the chemical elements to the photosynthetic and accompanying metabolic processes of the higher green plants, which characteristically distinguishes them from all other types of organisms.

Finally, no attempt is made at this time to correlate the observed phenomena with the more recent explanations of atomic structure and chemical reactivity of the elements themselves. On the contrary, in all this discussion, the terms used are always those of the older and more commonly understood properties of valence, acid- or base-forming possibilities, ionic dissociation, etc.

Proposed Classification

The proposed classification of the chemical elements with respect to their functions in plant nutrition is based on the general conception that the green plants are the energy-absorbing and energy-storing agents of the cycle of life. Animals use these plants as foods, or as fuels, to supply the energy necessary for their life processes. Of course, green plants respire and otherwise consume energy, but the general result of their growth process, culminating in the production of seeds with their storage reservoirs of energy for the starting of a new generation, is the synthesis of easily oxidizable carbohydrates, fats, proteins, etc., with high energy-producing possibilities. Based on this general conception, the following classification of the elements which are known to, or may possibly, play a definite rôle in the synthetic processes of the higher green plants and hence are required by them as nutrients, is proposed:

Group I. Hydrogen and oxygen; *energy exchange elements.*

Group II. Carbon, nitrogen, sulfur and phosphorus; anion (or acid) group formers, with varying valence; *energy storers.*

Group III. Sodium, potassium, calcium and magnesium; cation (or base) formers, with fixed valence; *translocation regulators.*

Group IV. Manganese, iron (cobalt and nickel), copper and zinc; cation (or base) formers, with varying valence; *oxidation-reduction regulators.*

Group V. Boron, aluminium, silicon, arsenic, selenium; ampholytes, with varying valence; *functions unknown.*

Group VI. Chlorine, fluorine (bromine and iodine); anion (or acid) formers, with fixed valence; *functions unknown.*

Group VII. Cobalt and nickel; cation (or base) formers, with varying valence; *functions unknown,* but perhaps those of Group IV.

Group VIII. Germanium, gallium and other rare elements; ampholytes; *functions unknown.*

The following discussions will serve to indicate the general basis for this classification:

Group I

Hydrogen and oxygen are universally present in plant tissues. Their separate addition to or removal

from any organic compound results in much greater energy exchange than is true of any other elements. In general, oxidation reactions (addition of oxygen or removal of hydrogen) release energy or are *exothermic;* while the reverse, or reduction, reactions absorb energy or are *endothermic.* The simultaneous addition or removal of two atoms of hydrogen and one atom of oxygen, the so-called "reversible hydrolysis" reactions, do not require energy exchanges of the type here considered and are *isothermic.*

GROUP II

The members of this group, located adjacent to each other in Groups IV to VI of the periodic table, are characteristically anion-formers. They exhibit varying valence and are therefore capable of combination with hydrogen and oxygen in varying proportions, with the consequent possibilities of large energy exchanges in their reactions.

They do not participate in organic reactions as elements, or as elemental ions, but always in groups in which they are linked with oxygen or hydrogen and sometimes other elements to form groups of widely varying complexity, properties and reactivity. In general, they are most easily taken from a nutrient solution by plants when in their most highly oxidized forms. In fact, with the exception of nitrogen, it may be said that they are assimilable by higher plants only when in this form. Further, the first stage in their utilization by such plants is their reduction to a very low, if not the lowest possible, stage of oxidation. (Phosphorus is an exception to this last statement, as will be noted below.) This is a highly endothermic process and is the beginning of photosynthesis, the energy necessary for it being obtained by the absorption of radiant solar energy. In their later oxidation, in both plant and animal tissues, they release their stored energy. Hence, their designation as "energy storers."

Groups I and II might also be called "the protoplasm formers," since they are the essential components of the carbohydrates, fats, proteins and nucleocompounds which constitute the active mass of colloidal matter of cellular tissues. It is for this reason, as well as its place in the periodic table and properties generally similar to those of the other elements of the group, that phosphorus is included in this group, in spite of the fact that it does not, like the others, undergo changes in stage of oxidation during its assimilation and metabolism by plants and consequently probably does not serve as an "energy storer."

GROUP III

The members of this group, while "essential elements" of plant nutrition, are not actual constituents of the principal organic components of protoplasm. Neither are they involved in the oxidation-reduction reactions which are the basis for energy exchange. This latter fact is probably because of their fixed valence and consequent inability to unite with varying proportions of oxygen and hydrogen.

They are, however, very definitely connected with most of the isothermic transformations of carbohydrates, fats and proteins from simpler (generally more soluble) forms to more complex (generally insoluble) forms and *vice versa.* In fact, they may be considered as serving as catalysts for the reversible hydrolysis of these compounds, whereby they are rendered soluble and capable of translocation from the cells in which they are synthesized to other cells, where they are utilized for energy production or stored in less soluble forms for future use.

Further, these cation-forming electrolytes have very definite effects upon the colloidal properties of cell protoplasm, whereby its permeability, its water imbibition capacity, its power of adsorption and its definite structure-forming capacity are altered so as to influence not only the direction and velocity of the hydrolytic reactions which go on in it, but also the ease or speed of removal from it by osmosis of the various products of such reactions.

In general, therefore, it is apparent that the elements of this group are chiefly concerned with the chemical reactions and colloidal phenomena which are essential to the translocation of compounds through the various tissues of the plant. Magnesium has an additional special and exceptional function in that it enters into the molecular composition of chlorophyll, but its function in this respect is not well understood, since it can be replaced in the chlorophyll molecule by iron, copper or zinc without greatly altering the light-absorbing properties or chemical reactivity of the chlorophyll. Potassium may have highly specific effects other than the general ones attributable to the group as a whole because of its radioactive properties. In fact, it is easily possible to conceive that there are specific functions for each of these elements in addition to those which are described comprehensively under the term "translocation regulators," but the latter seems to express fairly correctly their major function in the energy absorption and storage process.

GROUP IV

The elements assigned to this group, if cobalt and nickel be included in it, constitute the six elements whose atomic numbers (25 to 30) place them adjacent to each other in the periodic table. In other words, their atomic structure differs only by the successive addition of one electron to the proton nucleus. With the exception of zinc (the highest member of the series), they all form both *ous* and *ic* compounds by variations in valence. Manganese and zinc at the two ends of the series both exhibit both acid- and

base-forming properties, but in general these six successive elements in the periodic system exhibit similar chemical properties and undoubtedly perform similar physiological functions in plant nutrition. With respect to cobalt and nickel, these functions have not yet been studied experimentally sufficiently to determine whether they are really important in plant nutrition, and they are therefore tentatively listed both in Group IV and Group VII of this proposed scheme of classification.

With respect to manganese and iron, and copper and zinc, however, I believe that there is sufficient experimental evidence to justify the hypothesis that these are two pairs of mutually coordinating catalysts for oxidation-reduction reactions, the former for biological reactions in which the addition or removal of oxygen is the basis of the energy exchange and the latter for those in which loss or gain of hydrogen is involved. I recognize that the matter has not yet been investigated sufficiently to establish fully the soundness of this hypothesis of the balancing effect of these two pairs of catalysts, but believe that there is adequate proof that their major function is that of catalysts of oxidation-reduction reactions in biological processes. While it is impracticable to cite in detail in this preliminary paper the experimental evidence bearing upon this particular phase of the matter, it may be briefly summarized as follows:

Iron and manganese have been shown to be mutually antagonistic in their production of chloroses of plants due to improper conditions for the production of chlorophyll. This has frequently been explained as a calcium-manganese antagonism, but recent experiments have shown that the true explanation lies in the rendering insoluble and unavailable of iron by excessive proportions of calcium in the nutrient medium or cell protoplasmic contents, thus disturbing the iron-manganese balance, instead of the calcium-manganese balance.

The basis for the belief that copper and zinc are mutually counter-balancing catalysts for hydrogen exchange lies in their recently demonstrated striking and opposite effects upon the reversible oxidation-reduction reactions of both glutathione and ascorbic acid. The theory that these two compounds, which are now known to be almost, if not quite, universally present together in rapidly metabolizing tissues of both plants and animals, constitute linked factors in the system of oxidation-reductions in protoplasm, has been suggested recently by several different investigators.

In short, it is my hypothesis that the iron-manganese pair constitute the controlling catalytic factors in oxidation-reduction reactions of the oxygen exchange, or chlorophyll and hemoglobin type, and that copper and zinc act similarly in the hydrogen exchange, or glutathione-ascorbic acid type of similar reactions.

In my laboratory, we are now engaged in an experimental study of the soundness of the second phase of this hypothesis, as a part of our study of the general problem of the function of rarer elements in plant nutrition.

GROUPS V–VIII

The functions in plant nutrition of the elements tentatively placed in these groups have not been investigated sufficiently to provide a basis for their grouping according to known uses for this purpose. They are therefore grouped according to their chemical properties as connected with their place in the periodic table, with the thought that this may afford a basis for further study of their possible plant nutrition functions.

It is possible, of course, that further investigational work will show that some of the elements which are found in the higher orbits of the periodic table have definite functions in plant nutrition. In fact, it has been suggested that rubidium, iodine and even lead, for example, may have some such functions; but the observations which lead to such suggestions appear to refer to some abnormal growth or environmental conditions and not to the general normal processes of plant nutrition. The list here presented includes all those elements which have been reported to be frequently found in the ash of plants grown under generally-occurring conditions of soil nutrient supplies the world over, and is therefore believed to include all those elements which need to be considered in a systematic study of this problem.

ENVIRONMENTAL TRANSFORMATION OF BACTERIA[1]

By Dr. W. H. MANWARING

PROFESSOR OF BACTERIOLOGY AND EXPERIMENTAL PATHOLOGY, STANFORD UNIVERSITY

RECENT morphological and physiological studies of specific infectious agents have led to tentative conclusions, which bacteriologists and immunologists are frankly incompetent to harmonize with the currently accepted theories of genetics and organic evolution.

These studies suggest a Lamarckian rather than a

[1] Presented as part of the symposium on "Environmental Effects on Plants," Western Society of Naturalists, Asilomar, Calif., December 27, 1933.

Darwinian world, or at least a world in which both Lamarckian and Darwinian evolutionary mechanics are operative.

I

During the first fifty years after the initial discoveries by Koch, Lister and Pasteur, the basic generalizations of post-Darwinian biology, as taught and understood by the average college student, formed the unquestioned axioms from which bacteriologists and immunologists deduced many of their most important technical methods. Methods for the specific diagnosis of human and veterinary infections, for their specific prophylaxis and specific therapy were all either direct or indirect applications of Mendelian logic. No method was suggested, for example, that was contrary to the accepted law that each and every disease germ must arise from a pre-existing microbe of at least approximately the same type or species. Spontaneous generation was unthinkable. Environmental synthesis of infectious units was never conceived. Transmutation of pre-existing microbes into wholly new species or genera was beyond belief. Even the possibility of the environmental induction or ongrafting of a single new hereditary character in bacterial cells never entered into practical clinical logic.

The earlier bacteriologists, of course, did not assume that laws governing the evolution and racial stability of higher animals and plants are equally applicable to disease germs, without some attempt at their statistical or experimental verification. They observed, for example, that environmental bacteria do not appear in heat-sterilized broth, under conditions which exclude the possibility of their entrance from the outside world. This was accepted as proof that spontaneous generation of microorganisms is impossible.

It was further noted that the amount of pigment produced by certain bacteria varies at different temperatures or on transplantation to a different type of culture medium. The changes thus produced, however, were apparently always quantitative and never qualitative in nature, thus conforming with Mendelian expectations. Moreover, the changes were apparently never permanent, the microorganisms reverting to their original parent type on return to their original environmental conditions. Acquired characters, therefore, are apparently not hereditarily transmissible in the bacterial world.

If a pure-line bacterial culture is "plated out," so that each bacterium multiplies to form an individual colony, "natural variations" were noted in pigment production. These, also, were always quantitative in character. By selective propagation, intensely pigmented and quasi-albino strains were eventually obtained. Both strains, however, tended to revert to the original parent type, on prolonged non-selective sub-culture. This selective improvement and subsequent non-selective reversion were both in accord with conventional preconception.

Gradual losses of virulence were noted on prolonged non-selective cultivation of pathogenic microorganisms on routine or overly favorable culture mediums. On injecting the attenuated cultures into laboratory animals, however, the microorganisms recovered at autopsy were usually of restored virulence, an apparent "survival of the fittest" in the resistant animal body. By repeated animal passage, strains of "exalted virulence" were eventually obtained, apparently demonstrating the applicability of post-Darwinian evolutionary mechanics.

Swollen, distorted, atypically staining, granular or vacuolated cells were often noted in old cultures, as well as shrunken cells, "shadow cells" and granular "debris." On attempting routine sub-culture from such "atypical" bacteria, growth often did not occur. If multiplication did take place, however, the resulting daughter cultures were apparently always of "typical" morphology and staining reactions. Any departure from the assumed "typical" microscopical appearance, therefore, becomes synonymous with "degeneration," "involution" or "necrobiosis."

II

It seemed apparent from these earlier studies that the laws governing hereditary, natural variation, racial stability and selective evolution in higher animals and plants could be applied without change to bacterial species. Serious doubt as to the infallibility of this logic, however, began to be entertained about five years ago, when careful restudies of bacterial stability were begun in a dozen research laboratories.[2] Pedigreed strains, known descendants from a single ancestral cell, were now seen to "dissociate" into from two to a dozen morphological, tinctorial, physiological or antigenic types. This dissociation was apparently far beyond the analogous mutation of higher animals and plants. Many of the "dissociates" were so different from the parent culture as to simulate wholly unrelated families, sub-families or genera. It is as though in higher biological science rats should mutate into mice, gophers and guinea pigs, or primroses, daisies and nasturtiums should appear among hybrid sweet peas.

Both "reversible" and "non-reversible" new races, species, genera or families were afterwards grown from scores of clinically important bacteria, the terms denoting the relative stability of the new variants. Certain of the new races reverted in the first subculture to their original parent type. Others have already been cultivated for three years on routine

[2] Hadley, Delves and Klimik, 1931.

culture mediums without showing a demonstrable tendency to revert.[3] This means approximately seventy-five thousand cyto-generations, the equivalent of seventy-five centuries with shelled amoeba, or seventy-five millenniums with many higher animals or plants. During this time, of course, transplants have been made by non-selective methods and the environmental conditions have been kept relatively constant.

Dissociation may and often does occur under apparently optimum cultural conditions.[4] With certain bacterial species, however, racial plasticity is more marked under slightly adverse growth conditions, such as an unfavorable surface tension, reduced barometric pressure or the presence of dilute chemical or biological antiseptics, such as semi-immune animal serum. The mere addition of sterile milk[5] to a routine culture medium allegedly causes the acid-fast tubercle bacillus (Order II, *Actinomycetales;* Family II, *Mycobacteriaceae;* Genus I, *Mycobacterium*) to transmute into a non-acid-fast coccus (Order I, *Eubacteriales;* Family II, *Coccaceae;* Genus I, *Diplococcus*). With proper preliminary selective care, this quasi-coccus can be grown indefinitely as an apparently stable new species.[6] Non-flagellated typhoid bacilli, non-capsulated pneumococci, Gram-negative diphtheria bacilli, as well as a host of other unconventional species or genera can be produced at will. Many of them show a non-selective racial stability equal to or even greater than that of the "undissociated" parent culture. Even viable colloidal granules beyond the range of microscopic visibility are alleged,[7] the hypothetical "gonidial granules," "primordial phases" or "virus phases" of certain specific infections.

Of the eleven presumably unit characters thus far studied with certain bacterial species, there is apparently not a single character that is static under test-tube conditions, nor is there the least suggestion of a genetic "linkage" between any two of these eleven characters. The currently assumed unit characters include such diagnostic properties as: size, morphology, staining reactions, colony type, power to ferment certain carbohydrates, pigment production, toxin production, racial specificity of fractional antigens and type of disease produced in laboratory animals. Even the specific virulences for two closely related animal species or for two different organs or tissues of the same species[8] may vary independently of each other.

III

There is conclusive evidence that all test-tube variants can not be explained as the result of merely quantitative variations in preexisting hereditary unit characters. The environmental induction of one or more new unit characters is fully confirmed,[9] the "emergent evolution" of an apparently new protein specificity, for example, no trace of which is demonstrable in the parent culture. It is as though blue roses should appear among the predicted red, orange, yellow and albino hybrids, a genetic impossibility to modern horticulturists.

"Convergent evolution" is an interesting by-product of this emergence, two practically identical hypermutants arising from two presumably unrelated bacterial species. It is as though, under appropriate environmental conditions, crows and robins should each mutate into bluejays, or pines and cedars metamorphose into redwoods.

During the last two years it has been increasingly evident that emergent and convergent bacterial evolutions are not mere test-tube curiosities. Similar hyper-mutations are known to occur during the course of natural clinical infections or as a result of experimental inoculation into lower animals. The primary and tertiary phases of *Tr. pallidum,* for example, are of such qualitatively different antigenic properties as to simulate two relatively distinct microbic species. *B. tuberculosis* is apparently diphasic[10] and perhaps even triphasic in effective antigenicity during the course of the natural clinical disease. Poliomyelitis virus is allegedly transmuted into a qualitatively different antirhesus variant, on repeated injection into monkeys.[11] This transmutation is associated with a remarkable increase in its antirhesus virulence, strongly suggesting that this transformation must be considered as evolutionary rather than degenerative in character.

Recent fractional analyses of hemolytic streptococci isolated from clinical cases strongly suggest their convergent transformation in the human body, the appearance of a stable, human-diagnostic, polysaccharide fraction,[12] no trace of which is demonstrable in homologous streptococci of veterinary origin. An anti-human fibrinolytic function recently demonstrated in such streptococci[13] is also suggestive of the same convergence.

IV

There is apparently convincing evidence that hormones, chemical "organizers" or integrating enzymes play an important rôle in stabilizing bacterial populations, and in initiating or inhibiting dissociations or transformation phenomena. The integrating

[3] Mackenzie and Fitzgerald, 1933.
[4] Knaysi, 1933.
[5] Maher, 1933.
[6] Miller, 1931; Mellon, 1931.
[7] Hadley, 1931.
[8] Webster and Clow, 1933.
[9] Mackenzie and Fitzgerald, 1933.
[10] Thomas, 1932; Rice, Orr and Reed, 1933.
[11] Paul and Trask, 1933.
[12] Lancefield, 1933.
[13] Tillett and Garner, 1933.

factor thus far studied in greatest detail is the type-specific "activator" of the pneumococcus.

Under routine cultural conditions the pneumococcus breeds true as a capsulated diplococcus, whose type-specific diagnostic character is due to the presence of a highly specialized capsular polysaccharide. Some of these capsular sugars are of known chemical composition. Under certain slightly adverse cultural conditions, however, the capsulated pneumococcus dissociates into a non-capsulated variant, in which the most delicate immunochemical test fails to reveal a trace of its original type-specificity polysaccharide. This naked variant may breed true for innumerable test-tube generations.

If, however, under certain serological conditions, a pure culture of this naked variant is enriched by the addition of an aqueous extract of alien-type pneumococci, the naked variant is "activated" to a regeneration of its outer defensive capsule.[14] The regenerated capsule, however, is not of the original type-specificity. The pneumococcus now manufactures a new capsular polysaccharide, apparently identical with that of the alien extract with which it was "fertilized." Thus hormonally hybridized to an alien type, the recapsulated pneumococcus breeds true for innumerable test-tube generations. It is as though albino crows stained with bluejay extract should transmute into a new and stable race of blue crows.

Similar hormonal transformations are alleged for the tubercle bacillus, an unknown hormone, for example, capable of transmuting the conventional waxy tubercle bacillus into a stable, non-waxy variant.[15] Of even greater clinical interest, however, is the rapidly increasing evidence that hormonal transformations even take place between widely different bacterial species or genera. It is well confirmed, for example, that partial functional and chemical convergence takes place between certain pathogenic and non-pathogenic bacteria of the gastro-intestinal type if grown together in the same fluid medium.[16] Even such widely different microorganisms as the streptococcus and the diphtheria bacillus demonstrably hybridize.[17] Unfortunately, however, from the point of view of medical research, the resulting symbiotic or synergistic hybrids are rarely stable, reversion to type almost invariably taking place on separating the two associated species.

V

While the mechanisms of most bacterial dissociations or transformations are unknown, there is one type of metamorphosis that has been studied in considerable detail. These are the transformations which take place under the influence of the Twort colloid (1915).

Freshly isolated typhoid bacilli, for example, grown directly from clinical cases, are usually aggressive in character.[18] This is shown by their resistance to certain biological antiseptics and by their power of digesting or "hemolyzing" certain relatively refractory red blood corpuscles. By the second or third sub-culture, however, these aggressive bacilli usually dissociate into ordinary, non-aggressive laboratory types, setting free an aggressive "cytoplasmic gene"[19] into the surrounding fluid medium. This dissociated gene (Twort colloid) is of approximately the same size as the average protein molecule.[20]

Dissociated bacterial genes of this type are apparently not fully autonomous vital units. So far as known, they are incapable of self-proliferation. Added to a routine non-aggressive laboratory strain of typhoid bacilli, however, the free genes are adsorbed, absorbed or conjugated with the bacteria[21] and now multiply or are multiplied in symbiosis with these cells. The reassembled "bacterium-gene complex" has the same aggressive properties as those of the freshly isolated typhoid bacillus. By proper technical methods the reassembled complex can be bred true for innumerable test-tube generations. Under routine cultural conditions, however, redissociation usually takes place.

This transmissible gene apparently has a dual or reversible function, depending upon other environmental factors. Under certain non-colloidal conditions, for example, the ingrafted gene apparently functions as a hereditary lethal factor. Multiplication of the complex continues for a predictable number of generations, after which proliferation ceases and the complex disintegrates, presumably as a result of autolysis. On disintegration, many thousand times the original number of ingrafted genes is set free in the surrounding fluid medium.

VI

Transmissible bacterial genes are apparently widely distributed in nature, being found, for example, in almost any contaminated surface water. These native genes are usually highly specific for one bacterial type, being capable of fruitful symbiosis only with this one type. Occasionally, however, a relatively non-specific or "polyvalent" gene is found, which is capable of successful hybridization with two or more bacterial species. A recently described "trivalent" gene,[22] for example, functions as a successful ingrafted lethal factor with three relatively distinct bacterial strains.

[14] Alloway, 1932, 1933.
[15] Miller, 1932.
[16] Lommel, 1926.
[17] Roux and Yerain, 1890; Wygodtachikoff and Manuilowa, 1930.
[18] Sonnenschein, 1928; Bianchi and Callerio, 1931.
[19] Alexander, 1934.
[20] Krueger, 1932.
[21] Northrop and Krueger, 1932.
[22] Bronfenbrenner, 1933.

Bacterial genes are not immutable in function or in chemical composition. By careful sub-pasteurization, the above-mentioned trivalent gene can be fractionally denatured. Thus partially inactivated, it functions as a strictly monovalent gene, capable of symbiotic proliferation with only one narrow bacterial strain. Grown in repeated symbiosis with this strain, however, its two heterologous, heat-inactivated valences are regenerated.

In the relatively stable bacterium-gene-complex, the bacterial cell apparently does not function as an inert "carrier" of the ingrafted colloid. An aqueous extract of the stable complex yields an apparently new colloidal factor,[23] a gene-inhibiting component, capable of preventing its potentially lethal action.

SUMMARY AND CONCLUSIONS

About the only conventional law of genetics and organic evolution that is not definitely challenged by current bacteriologists is the nineteenth century denial of the possibility of spontaneous generation of bacterial cells. Even this is questioned by certain recent theorists in their hypothetical transformation of certain normal enzymes into "pathogenic genes" or "filterable viruses,"[24] and in their apparently successful synthesis of "Twort genes" by the chemical oxidation of certain heat-sterilized organic products.[25]

Whether or not future refinements in immunochemical technique can or will bridge the gap between the apparent Lamarckian world of bacteriology and the presumptive Darwinian world of higher biological science is beyond current prophecy.

OBITUARY

GEORGE OWEN SQUIER

MAJOR GENERAL GEORGE O. SQUIER (retired), distinguished army officer, engineer, inventor and applied scientist, died at Washington, D. C., on March 24, 1934.

George O. Squier was born at Dryden, Michigan, on March 21, 1865. He early showed marked ambition for advancement. At 18 years of age he entered the West Point Military Academy, where he graduated in 1887. In later years, he used to tell fascinating stories of West Point cadet life that would have made interesting reading had they been published.

After leaving West Point, he was appointed a second lieutenant in the 3rd Artillery. Desiring originally to pursue scientific studies in the field of ballistics, he entered the Johns Hopkins University as a graduate student, and received a degree of doctor of philosophy in 1893. He then returned to the Artillery Corps and became instructor at the U. S. Artillery School at Fortress Monroe, Virginia, from 1895 to 1898.

At the outbreak of the war with Spain in 1898, Dr. Squier sought service in the Signal Officer Volunteers and entered with the grade of captain. In this service, he was sent to the Philippine Archipelago, in 1900, where he commanded the cable ship, *Burnside,* and laid a system of submarine cables between strategic points in the islands. After the war, he was appointed first a captain, later a major in the U. S. Signal Corps and became chief signal officer in the California district.

It was during this period that he took up the study of army cable and radio communication, and published several papers in this field. Major Squier discovered that a growing tree could serve as a receiving radio antenna if a nail was driven into it fairly high up and a wire brought down from the nail to the receiving instrument. As a corollary to this proposition that trees and their branches have sufficient conductance to serve as antennas, he showed that forests, shrubs and vegetation generally, act as partially absorbent media for radio waves passing over land areas. He also made a study of aviation, then in its early stages of development. In 1908, Major Squier had been the first passenger of the world aviation pioneer, Orville Wright, in the latter's early form of airplane at Fort Myer. Twenty years later, the two men met in Washington to compare their aviation experiences.

From 1912 to 1916, Lieutenant Colonel Squier was a military attaché to the U. S. Embassy at London, where he made a special study of European military aviation and where the British army authorities gave him special facilities for investigation. He was a close observer of the British technical radio and aviation preparations during the first two years of the world war. The U. S. Ambassador to Great Britain at that time, Walter H. Page, wrote a glowing account in his Memoirs of Colonel Squier's services in London. Recalled to America in May 1916, Brigadier General Squier was put in charge of the U. S. signal service as chief signal officer. He organized and administered the electrical communication service between the American Expeditionary Force in Europe and its bases in America, using for that purpose radio, cables and wires. This service continued until two years after the war. He was raised to the rank of major general in 1917, and later received the distinguished service medal (D. S. M.) for his services.

[23] Levine and Frisch, 1933.

[24] Vinson, 1931.

[25] LeMar and Myers, 1933.

As an inventor, Major Squier won fame in discovering the method of communicating messages over wires by modulating inaudible frequencies—the so-called "wired wireless." He also invented the "quick-aid" kit for Army and Red Cross first-aid work. He greatly developed radio and telegraph service in the U. S. Signal Corps.

General Squier was notable for his swiftness of judgment and earnestness of purpose. His wiry erect bearing and purposeful demeanor marked him at once as a military officer. He was punctual and precise in all engagements, while cheerfully putting late arrivals at their ease. He used to say that one of the many gifts of radio to the world was the radio announcer's habit of broadcast punctuality. General Squier was a hard worker and faced every task with cheerfulness and courage. He was never married, but he was a family friend in numerous homes. With the aid of his sister, Mrs. Mary Squier Parker, who survives him, he built a "country club for country people" at his birthplace, Dryden, where he succeeded in giving summer country associations to many of his friends and fellow townspeople. After his retirement from the army in 1924, he frequently spent his winters in Florida and the other seasons in Washington and Dryden. Wherever he went, General Squier brought brightness and enjoyed popularity. His staff was enthusiastic in its praise and esteem for him.

Numerous honors were bestowed on General Squier both in this country and abroad. Only an abbreviated list can be given here. He was Commander of the French Legion of Honor, a Knight Commander of St. Michael and St. George in Great Britain, a Commander of the Order of the Crown of Italy and a member of the Royal Institution of Great Britain. General Squier held membership in the National Academy of Sciences, the American Philosophical Society and was a fellow of Johns Hopkins University. He also received an honorary degree from Dartmouth College. General Squier was a life member and fellow of the American Institute of Electrical Engineers. He received from the Franklin Institute, the John Scott Medal in 1896, the Elliott Cresson Medal in 1912, and the Franklin Medal in 1919. A number of electrical papers were communicated to the *Journal of the Franklin Institute* as well as to the *Proceedings* of the American Institute of Electrical Engineers by General Squier.

General Squier served on various international commissions relating to military and radio affairs.

He was given a military funeral and laid to rest in Arlington National Cemetery, Virginia.

A. E. KENNELLY

RECENT DEATHS

DR. EDWARD WILLIAM NELSON, chief of the Federal Bureau of Biological Survey from 1916 to 1927, died on May 19. He was seventy-nine years old.

DR. ULYSSES GRANT HOUCK, for thirty-eight years associated with the Bureau of Animal Industry of the U. S. Department of Agriculture, and since 1928 its associate chief, died on April 25 at the age of sixty-eight years.

THE death is announced of Dr. Andrew M. Soule, until last year president of the Georgia State College of Agriculture. In 1904 he became dean of the college of agriculture and director of the Agricultural Experiment Station at Virginia Polytechnic Institute and held that position until 1907, when he went to Georgia State College of Agriculture.

CECIL HOBART PEABODY, since 1920 professor emeritus of naval architecture at the Massachusetts Institute of Technology, died on May 4 at the age of seventy-nine years.

DR. GEORGE PAUL LAROQUE, professor of surgery at the Medical College of Virginia, at Richmond, died suddenly on May 16. He was fifty-five years old.

DR. LOUIS DE LOTBINIERE HARWOOD, professor of gynecology and dean of the faculty of medicine of the University of Montreal, died suddenly on May 15.

DR. ROBERT CHODAT, since 1889 professor of botany at the University of Geneva, director of the Botanical Institute, has died at the age of sixty-nine years.

SCIENTIFIC EVENTS

THE ABERDEEN MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE annual meeting of the British Association for the Advancement of Science will be held at Aberdeen from September 5 to 12, under the presidency of Sir James H. Jeans.

The first visit of the British Association to Aberdeen took place in 1859, when H. R. H. the Prince Consort was president and delivered an inaugural address. The association again met in Aberdeen in 1885, under the presidency of Sir Lyon Playfair.

The inaugural general meeting will take place on the evening of September 5, when Sir James H. Jeans will deliver his presidential address on "The New World-Picture of Modern Physics." Sir James Jeans was appointed by the general committee on March 2 as president of the association for the current year, in

succession to Sir William Hardy, who died on January 23.

The presidents of the sections, with the titles of their addresses, are as follows:

Section A (Mathematical and Physical Sciences): Professor H. M. MacDonald, "Theories of Light."

Section B (Chemistry): Professor T. M. Lowry, "Physical Methods in Chemistry."

Section C (Geology): Professor W. T. Gordon, "Plant Life and the Philosophy of Geology."

Section D (Zoology): Dr. E. S. Russell, "The Study of Behavior."

Section E (Geography): Professor A. G. Ogilvie, "Cooperative Research in Geography and an African Example."

Section F (Economic Science and Statistics): Professor H. M. Hallsworth, "The Future of Rail Transport."

Section G (Engineering): Professor F. G. Baily, "Sources of Cheap Electric Power."

Section H (Anthropology): Captain T. A. Joyce, "The Origin and Use of Yerba Maté."

Section I (Physiology): Professor H. E. Roaf, "Normal and Abnormal Color Vision."

Section J (Psychology): Dr. Shepherd Dawson, "Psychology and Social Problems."

Section K (Botany): Professor A. W. Borthwick.

Section L (Educational Science): Mr. H. T. Tizard.

Section M (Agriculture): Professor J. A. S. Watson, "Scientific Progress and Economic Planning in Relation to Rural Industry and Country Life."

An evening discourse, being a Memorial Lecture for the late president, Sir William Hardy, will deal with the preservation of meat, fish and fruit, and will be delivered on September 7. A second evening discourse will be delivered by Professor W. L. Bragg, on September 10, on "The Exploration of the Mineral World by X-rays." It is hoped that it will be possible to arrange an evening symposium on the general relation between Science and the Community on September 11. The title and speakers will be announced later.

A civic reception will be held by the Corporation of Aberdeen in the Art Gallery Buildings on the evening of September 6.

An extensive program of excursions and visits has been arranged for September 8.

It is anticipated that a garden party will be given by the University of Aberdeen on the afternoon of Tuesday, September 11.

Preceding the meetings an excursion of a fortnight's duration is planned. This is being organized as a "Reunion Internationale pour l'étude du Précambrien et des vieilles chaînes." Membership is by invitation and particulars can be obtained from the Local Secretary, Dr. W. J. McCallien, University of Glasgow. This excursion starts at Glasgow on August 18 and terminates at Edinburgh on September 2. On September 3 and 4 the Geological Society of Edinburgh are celebrating their centenary, under the presidency of Sir J. S. Flett. Details of the meeting may be obtained from the secretary, J. A. Watson, Edinburgh Geological Society, Synod Hall, Edinburgh.

At the close of the meeting, a series of excursions from Huntly as center is being arranged to last from September 12 to 16. The Huntly complex will be studied and visits paid to Elgin, the Portsoy-Banff district and Gamrie. Those interested should communicate with Dr. A. Bremner, 13 Belgrave Terrace, Aberdeen.

THE NATIONAL FISHERIES PLANNING COUNCIL

The Fisheries Survey Bulletin reports that at a meeting called by Commissioner Frank T. Bell, of the U. S. Bureau of Fisheries, on April 23 at St. Louis, at which representatives of the fish and game departments from every section of the country were present, "The National Planning Council of Commercial and Game Fish Commissioners" was formed. The council will coordinate the work in fisheries administration of the various states and the Federal Bureau of Fisheries, thus avoiding much of the duplication of effort which has been prevalent in the past.

In considering plans to perfect a workable program for the country as a whole the states were grouped into five zones as follows: Western Zone—Washington, Oregon, California, Nevada, Montana, Utah, Arizona, Idaho, Wyoming, Colorado and New Mexico; Midwest Zone—North Dakota, Minnesota, Iowa, South Dakota, Nebraska, Kansas, Missouri and Oklahoma; Southern Zone—Texas, Louisiana, Arkansas, Mississippi, Tennessee, Alabama, Georgia, Florida, South Carolina, North Carolina, Virginia and Maryland; North Central Zone—Wisconsin, Illinois, Indiana, Kentucky, Michigan, Ohio and West Virginia, and North Atlantic Zone—Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont and Maine.

A chairman was selected for each zone and representatives of the various states in each zone are to meet to discuss their problems at least once in three months with their chairman, or more often if the occasion arises. The Commissioner of the Federal Bureau will then meet with the various zone chairmen at least twice a year.

The *Bulletin* points out that under this system, it is possible for the states having like problems in the fisheries field to coordinate closely their plans and at the same time maintain a harmonious, cooperative program with the Federal Bureau of Fisheries. It

will be possible then to budget the fish stocking program of the zone as well as the country as a whole. The overlapping of fish planting in some sections and the complete lack of stocking in others can thus be avoided, and the regulation of the commercial fisheries can be coordinated.

The council elected the following men as their officers for the ensuing year: *Chairman,* I. T. Quinn, fish and game commissioner of Alabama; *Vice-chairman,* James G. Hammond, fish and game commissioner of Connecticut; *Secretary-Treasurer,* Ted Little, of the U. S. Bureau of Fisheries. Commissioner Frank T. Bell was named honorary chairman. The zone chairmen for the various zones are: Western Zone, M. F. Corrigan, president, Board of Game Commissioners of Oregon; Midwest Zone, W. C. Buford, fish and game commissioner of Missouri; Southern Zone, W. E. McIntyre, chairman of the Board of Fish and Game Commissioners of Alabama; North Central Zone, Fred A. Westerman, in charge fish and fisheries, Department of Conservation, Michigan, and North Atlantic Zone, Major James Brown, commissioner of fish and game, Vermont.

THE RECENT DESTRUCTIVE DUST CLOUD

THE dust cloud which recently swept over nearly half the United States originated largely on overgrazed semi-arid lands and on former cattle range land plowed for wheat near the eastern side of the Rocky Mountains, according to the Forest Service. Drought conditions extending eastward across the Mississippi permitted soil from midwestern states to blow as far as the Atlantic Ocean, darkening the skies over the National Capital and other cities.

Permanent damage to land as well as current damage to crops will result from such dust clouds, says the Forest Service, pointing out that although the dust storm is a new phenomenon to the people in the East, it is becoming increasingly common over wide areas of the Great Plains. For several years reports of wheat crops being blown out of the ground and highway and street traffic becoming snarled in clouds of dust have been coming from those regions, despite the fact that the velocities of winds do not seem to have increased. A statement recently issued by E. A. Sherman, associate forester of the Forest Service, said:

> That is the way deserts start. Excessive grazing, which destroys the protective vegetative cover and permits the ground to be trampled into dust, and the plowing up of naturally well sodded grazing lands for grain crops make it easy for the wind to whip away the dry soil and develop into a destructive dust storm. Wind erosion on the plains is like water erosion in states farther east in its power to destroy rich land in a few years and to transform broad stretches of country into devastated badlands.
>
> Unless more conservative grazing is practised on semi-arid land and unless greater care is exercised in plowing up extensive areas for wheat production in regions subject to drought, desert conditions will begin, and once established, these lands can never be reclaimed.
>
> It is a mistake to cut down or burn up forests or to plow up sods in regions where the elements tend to cause accelerated erosion. Badly managed grazing may be equally destructive of land fertility, and carries with it menace of floods as well as dust storms. Within the last year or two, the country has also had examples of mudflows from overgrazed ranges and from burned-off areas, which cost human lives and heavy property losses. The nation should take warning from the present disastrous dust storm, and adopt measures to avoid future damage.

The Forest Service recommends that serious consideration be given to the preservation of the areas thus threatened. Large areas of range and plowed lands should be revegetated, put back to growing grass. Good management requires that grazing and use of these lands should be regulated to prevent further destruction. In some regions more shelterbelts of trees are practical and desirable. Much more is at stake than the lands already devastated, say the foresters. If steps to revegetate these lands and protect other lands are not taken promptly, vast areas will in a few years be under constant threat of dust storms and distressing droughts.

GOVERNMENT APPOINTMENTS FOR CIVIL ENGINEERING GRADUATES FROM SYRACUSE UNIVERSITY

IN 1929 the Guggenheim Fund for the Promotion of Aeronautics gave a grant of $60,000 to Syracuse University for the development of work in aerial mapping and surveying in the College of Applied Science.

In addition to a number of publications which have been issued in connection with this work, there has been an increased demand for students who are trained in this branch of engineering.

The department of aerial photographic surveying in the College of Applied Science has recently been asked to furnish several engineers for the extensive aerial survey work now being undertaken by the U. S. Forest Service in Washington. Professor Earl Church has received notification from the director of surveys of the Eastern Department of the Forest Service that sixteen of the civil engineering graduates of the College of Applied Science, who have taken the work in aerial photographic surveying under his direction, have been selected to receive appointments. These include eleven of the men who have been graduated previously to this year and the five members of the present senior class who are now taking this work.

The Forest Service is undertaking the project of mapping about 10,000 square miles by aerial photographic methods. Contracts have been awarded for the photographing of about 7,500 square miles of this area. It is difficult to obtain engineers for this undertaking who are familiar with the interpretation of aerial photographs by the use of stereoscopes and who have been instructed in the fundamental principles involved in the map compilation. The training in this work which has been offered at Syracuse University for the past few years by virtue of a grant for initial equipment from the Guggenheim Fund specifically prepares engineers for this modern method of surveying and has made it possible for this large group of civil engineering graduates to enter this field.

W. H. Baker, of Lafayette, N. Y., and R. T. Hedden, of Robinson, Illinois, both of the class of 1931, and M. K. Linck and George Schmidt, of Syracuse, of the class of 1932, have been chosen to receive appointments as photogrammetrists. This position entails a considerable amount of responsibility, for these men will be placed in direct charge of offices where the technical work of map compilation will be carried on.

THE AWARD OF STERLING FELLOWSHIPS AT YALE UNIVERSITY

THE Yale Graduate School has announced the award of 168 fellowships and scholarships for the academic year 1934–35. The recipients have studied in the graduate and undergraduate schools of 92 American colleges and universities; the Universities of Munich, Hamburg, Freiburg, South Africa, New Zealand, London; McGill University, the College of Yale-in-China and Cambridge University. They are residents of thirty-four states and Canada, China, England, Germany, Korea, New Zealand and South Africa.

The most important awards are the Sterling fellowships which are given annually to scholars who already hold the degree of doctor of philosophy or its equivalent. Twenty Sterling fellows have been appointed for next year.

These include the following in the sciences: Tze Tuan Chen, of Foochow, China, will extend his present study of the mechanism of heredity among some unicellular organisms; and Dr. Ernest C. Pollard, of Lincolnshire, England, will continue his investigation of the light atomic nuclei by observation of their disintegration under alpha-particle bombardment. Dr. Charles D. Aring, of Cincinnati, Ohio, will work on problems of localization in the cerebral cortex.

The Bishop Museum fellowships, established under an agreement between the Bernice P. Bishop Museum in Hawaii and Yale University to promote scientific investigations within the Pacific Ocean region, have been awarded to Dr. Horace B. Baker, of the Department of Zoology, of the University of Pennsylvania; and for a second year to Dr. Ernest Beaglehole, an anthropologist from Wellington, New Zealand.

SCIENTIFIC NOTES AND NEWS

THE Boston Society of Natural History has awarded the Walker Grand Honorary Prize of $500 to Professor William Berryman Scott, of Princeton University, for "his half century of conspicuous effort to advance the science of vertebrate paleontology in North America." Professor Scott is professor emeritus at Princeton University, where he held the Blair professorship of geology and paleontology from 1884 to 1932. The Walker Grand Prize is awarded once in five years by the society from a trust fund donated by Dr. William J. Walker in 1864 "for such scientific investigation or discovery in natural history as the society may think deserving thereof, providing such investigation or discovery shall first have been made known and published in the United States."

FOR his contributions to the study of music, Dr. Carl E. Seashore, professor of psychology and dean of the graduate college at the University of Iowa, was honored for the seventh time on May 22 with an annual commemorative concert. Dr. Seashore plans to retire as dean of the Graduate College in 1935. He asked to be relieved of administrative work this spring in order to devote more time to research, but was persuaded to continue the deanship for another year. Dr. Seashore, who has been connected with the university since 1897, has been head of the department of psychology since 1902 and has served as dean for twenty-six years.

A PORTRAIT of Dr. Harold Dickinson Senior, professor of anatomy at New York University and Bellevue Medical College, was recently presented to the college by the faculty, alumni and student body. The portrait was painted by Charles R. Boynton in recognition of Dr. Senior's twenty-five years of service in the college. Dr. Benjamin Spector, professor of anatomy at Tufts Medical College, who made the presentation, reviewed Dr. Senior's work and spoke of the affection and esteem in which he was held by his students and associates.

DR. LEON J. MENVILLE, assistant professor of medicine and roentgenology at the Tulane University of Louisiana School of Medicine, New Orleans, was presented with the medal of the Louisiana Academy of Sciences at its recent annual meeting, for his paper

on "The Possible Application of a Visualized Lymphatic System to the Cancer Problem."

THE University of Cambridge on May 1 conferred the doctorate of science on Dr. Alfred Fowler, Yarrow research professor of the Royal Society and professor of astrophysics at the University of London.

THE University of Madrid on April 7 conferred honorary doctorates on Professor H. E. Armstrong, emeritus professor of chemistry at the City and Guilds College, South Kensington, London, and on Dr. Robert Robinson, Waynflete professor of chemistry at the University of Oxford.

THE Garton Prize of £500 and Gold Medal of the British Empire Cancer Campaign has been awarded to Dr. H. A. Colwell, of Middlesex Hospital, London, for an essay on "The Biological Effects and Mode of Action of Radiations upon Malignant and other Cells." A second award of £100 has been made to Dr. F. G. Spear in association with Dr. R. G. Canti, Mr. L. G. Grimmett, Dr. B. Holmes, Miss S. F. Cox and Dr. W. H. Love.

THE Jacksonian Prize of the Royal College of Surgeons, London, for 1933, has been awarded to Edgar Samuel John King, of the University of Melbourne and Melbourne Hospital, for his essay on "The Pathology, Diagnosis, and Treatment of Localized Rarefying Changes in Bones." A certificate of honorable mention for an essay on the same subject was awarded to Mr. H. Jackson Burrows, of St. Bartholomew's Hospital, London. The John Hunter Medal, with the Triennial Prize for 1931–33, was awarded to Dr. Dorothy S. Russell, for her work on the morbid histology of the kidney and brain.

THE Sir Charles Hastings Clinical Prize of £50 for the promotion of observation, research and record in general practise has been awarded by the British Medical Association for 1934 to Dr. Helen Lukis, of New Malden, for her clinical study "The Problems of Anesthesia in General Practise." The Katherine Bishop Harman Prize of £75, given every two years for the encouragement of study and research in avoiding the risks of child bearing, has been given to Professor J. M. Munro Kerr, of Glasgow.

AT the recent annual meeting in New York of the American Society of Mammalogists, the following were elected officers for the ensuing year: Vernon Bailey, *president;* H. E. Anthony and T. S. Palmer, *vice-presidents;* Robert K. Enders, *recording secretary;* Robert T. Hatt, *corresponding secretary;* Viola S. Snyder, *treasurer;* Edward A. Preble, *chairman, editorial board.* Directors elected for the class of 1934–1936 were: Charles C. Adams, Rudolph M. Anderson, Lee R. Dice, W. K. Gregory, H. H. T. Jackson.

THE eleventh initiation meeting of the Virginia Chapter of Sigma Xi was held on April 25. The meeting was addressed by Dr. George H. Parker, director of the Zoological Laboratories of Harvard University, who spoke on the "Transmission of Neurohumors." The tenth annual award of the President and Visitors Research Prize of one hundred dollars was awarded to Dr. Carl C. Speidel, of the School of Anatomy, Department of Medicine, for a paper entitled "Studies of Living Nerves." The Andrew Fleming Prize of fifty dollars for the best paper in biology by a graduate student of the School of Biology was awarded to Ladley Husted. The John Horsley Memorial Prize in Medicine was awarded to Dr. Oscar Swineford, Jr., instructor in medicine in the University of Virginia, for a paper bearing the title "The Specific Control of Experimental Serum Reactions."

THE following officers of the Royal Institution, London, were reelected at the annual meeting held on May 1: *President,* Lord Eustace Percy, M.P.; *Treasurer,* Sir Robert Robertson; *Honorary Secretary,* Major Charles E. S. Phillips. The fifteen managers elected included Lord Melchett, Sir James Crichton-Browne, Sir Herbert Jackson, Professor C. S. Myers, Professor F. G. Donnan, Professor G. E. Gask, Dr. C. V. Drysdale, Dr. G. W. C. Kaye and Dr. C. H. Merz.

DR. ALFRED SHERWOOD ROMER, professor of vertebrate paleontology at the University of Chicago, has been elected professor of biology at Harvard University.

DR. HAROLD C. UREY, associate professor of chemistry at Columbia University, has been promoted to a professorship.

DR. ARTHUR C. BACHMEYER, dean of the University of Cincinnati College of Medicine for the past nine years, recently submitted his resignation. Dr. Bachmeyer will continue as superintendent of the Cincinnati General Hospital and as professor of hospital administration.

DR. GEORGE F. ZOOK, U. S. Commissioner of Education, has resigned to accept the directorship of the American Council on Education. His resignation will become effective on July 1. He will be succeeded by John Ward Studebaker, who has obtained leave of absence for one year from the superintendency of schools at Des Moines, Iowa. Dr. Zook, who before his appointment as Commissioner of Education was president of the University of Akron, recently declined an invitation to become president of the State University of Iowa.

CHARLES HENRY KUNSMAN, acting chief of the Fertilizer Laboratory of the Bureau of Chemistry and Soils, Washington, D. C., has been appointed chief of the laboratory.

C. P. CLAUSEN, who has conducted several insect exploration trips to the Far East, will be in charge of a new division of foreign parasite introduction which has been established in the Bureau of Entomology of the U. S. Department of Agriculture, to direct the importation of parasites and other natural enemies of crop insect pests.

Nature reports that Dr. R. Madwar has been appointed director of Helwan Observatory, near Cairo, in succession to P. A. Curry, who is the deputy director general of the physical department of the Ministry of Public Works, Egypt.

DR. J. HARTMANN, since 1922 director of the Observatory of the National University at La Plata, Argentina, has asked to be relieved from this post on account of failing health, and Ing. Félix Aguilar has been elected to succeed him. Ing. Aguilar was in charge of the observatory from 1915 to 1920 and since 1922 has been chief of the division of geodesy of the Instituto Geográfico Militar, in Buenos Aires. Dr. Hartmann will return to Germany.

FRANK W. LOVEJOY, who joined the Eastman Kodak Company as a chemist thirty-seven years ago, has been elected president. Mr. Lovejoy has been vice-president of the company since 1919 and general manager since 1925. He succeeds William G. Shuler, who has become chairman of the board.

DR. MARSTON T. BOGERT, professor of organic chemistry at Columbia University, has been appointed chairman of a committee to consider a federation of American chemical societies.

DR. Z. P. METCALF, professor of zoology at the State College of Agriculture and Engineering of the University of North Carolina and entomologist of the Experiment Station, Raleigh, has been appointed a member of the committee to survey the research work on cotton insects of the U. S. Bureau of Entomology.

DR. WILLIAM H. F. ADDISON, professor of histology and embryology at the University of Pennsylvania, who has been studying in Madrid in the laboratories of Dr. P. del Rio Hortega, will return in June.

DR. MARGARET C. FERGUSON and Dr. Alice M. Ottley left Wellesley in February for a seven months' trip through southern Arizona, Texas, New Mexico and Mexico, where they are collecting specimens of the flora for the herbarium at Wellesley College.

THE annual Alpha Omega Alpha dinner and lecture will be held at the time of the annual meeting of the American Medical Association in Cleveland at the Hotel Statler on the evening of June 14. Dr. Lewellys F. Barker will give the principal address. He will speak on the life of the late Dr. William H. Welch.

"THE Rift Valleys of Central Africa" was the subject of a lecture delivered on May 24 at the University of Minnesota by Dr. Bailey Willis, professor of geology at Stanford University. He spoke under the auspices of the department of geology.

DR. OTTO STRUVE, director of the Yerkes Observatory and of the McDonald Observatory, recently gave a lecture at the University of Texas entitled "Some of the Work That is Being Done with Large Telescopes."

DR. ARNO B. LUCKHARDT, of the University of Chicago, president of the American Physiological Society, delivered two lectures recently before the Medical School of the University of Minnesota. His subjects were: "Academic, or Unsuccessful, Research" and "An Adventure in Research—Ethylene Anesthesia." The lectures were sponsored by the Graduate School and the Minnesota Chapter of Sigma Xi.

DAVID DIETZ, science editor of the Scripps-Howard newspapers, was guest of honor at a tea given by the Buffalo Museum of Science on May 3. On May 4, Mr. Dietz delivered an illustrated lecture on astronomy entitled "A Trip through the Universe."

THE third Spiers' Memorial Lecture of the Faraday Society was delivered at the Royal Institution, London, on May 16 by Sir William Bragg, who spoke on "Molecule Planning."

THE 193rd regular meeting of the American Physical Society will be held in Ann Arbor, Michigan, on Friday and Saturday, June 29–30, 1934. The society will be the guest of the University of Michigan. Tentative plans for the program consist of a special address by Professor George Gamow, of the Polytechnical Institute, Leningrad, Russia; a symposium on hyperfine structure; one half day for the reading of ten-minute contributed papers; an excursion to the Ford plant and to Ford's museum at Dearborn, and a picnic supper at a near-by lake. It is hoped that all visitors may be entertained in one of the university dormitories. Other meetings for the current season are as follows: June 18–23, 1934—Berkeley, California, joint meeting with A.A.A.S.; November 30–December 1, 1934—St. Louis, Missouri; December, 1934—Pacific coast, time and place to be announced later; annual meeting, December 27–29, 1934—Pittsburgh, Pennsylvania.

THE American Society of Mammalogists held its sixteenth annual meeting at The American Museum of Natural History on May 8 to 12. A program of fifty papers was presented. At the business meeting a resolution was passed protesting the passage of House Resolution No. 8639, a bill removing all protection from the sea-lions of Alaska, a matter which the society deems without economic advisability, and one threatening the existence of these animals.

AT the annual meeting recently held in New York City the secretary of the American Society of Biological Chemists was instructed to give publicity to the following motion which was passed: "The American Society of Biological Chemists favors the passage of a more stringent food and drugs act, so designed as to afford ultimate protection for the consumer."

IT is reported from the University of Michigan that the university has received as a gift from the Pennsylvania Salt Manufacturing Company, of Wyandotte, Michigan, 2,500 gallons of water which will after treatment produce at least two quarts of "heavy water."

BY the will of the late Mrs. Helen Hartley Jenkins $50,000 is added to the principal of the Marcellus Hartley chair of medicine, which Mrs. Jenkins founded several years ago in the medical department of New York University. Among other public bequests was one providing $2,000 for the training of a nurse for three years in the Department of Nursing and Health at Columbia University and Morristown Memorial Hospital.

THE sixth International Congress on Industrial Accidents and Diseases offers a prize of 1,000 Swiss francs as an award to the author of the best (unpublished) original work on the subject, "The Importance of Previous Physical Condition in Estimating the Sequelae of an Industrial Accident." Physicians in all countries are permitted to take part. Manuscripts must be in hand by December 31, 1934. The award will be made at the time of the seventh congress to be held in Brussels, mid-July, 1935. Those interested should communicate with Dr. Fred H. Albee, 57 West 57th Street, New York City, or Dr. Emery R. Hayhurst, Ohio Health Department, Columbus.

BRITISH INDUSTRIES HOUSE, near Marble Arch, is being equipped as a permanent exhibition center at which wholesale buyers may find, conveniently grouped, many different kinds of British and Empire merchandise. The extensive third floor and the basement have been allotted to a medical section, containing showrooms, showcases and manufacturers' sample and pattern rooms for the display of supplies and appliances used by hospitals, doctors and chemists. The London *Times* reports that the medical center will be officially opened on July 18, to enable delegates to the annual conference of the British Medical Association to be present before assembling at Bournemouth, where their conference will begin the next day. Delegates to the British Hospitals' Association conference in June will similarly be invited to visit the center. It will be run with the guidance of an advisory committee, of which the chairman will be Dr. Alfred Cox, who till 1932 was medical secretary of the British Medical Association.

DISCUSSION

SPIRALITY IN THE GROWTH OF WOOL FIBERS

RECENT issues of SCIENCE contain various references to the spiral habit of growth in organisms.[1] Among the many examples given, in both plants and animals, no mention is made of the hairs of mammals, though in these spirality in one form or another is of general occurrence. Special attention has recently been directed to its prevalence in the wool fibers of sheep, where it is of some industrial significance. Its expression, however, tends to be obscured by periodic reversals in the direction of rotation, resulting from an axial twisting of the fibers superimposed on the fundamental spirality. Moreover, wool fibers are rarely disposed singly, but are aggregated into wavy tufts or staples to the contours of which the constituent fibers closely conform.

The simplest expression of spirality in wool is to be found in the well-known curly tufts which for the most part constitute the coat of the new-born lamb. Some of these are represented in Fig. 1 (a–e), where the close spiral whorls above indicate the prenatal or prototrichial growth, and the more open turns below the early postnatal or definitive growth, the former persisting on the fleece as apical tips to the latter. The first staple, Fig. 1a, is from a five months' South Devon lamb. With the addition of new fibers the simple spiral increases in diameter and pitch from above downwards and passes directly into the definitive part of the staple, which is more openly spiral. The direction of rotation, positive or negative, right- or left-handed, clockwise or counter-clockwise, varies in the different staples, the number one way or the other being about equal, showing it to be a matter of indifference.

Fig. 1b represents a more usual form of staple from the same fleece, where the direction of rotation of the spiral undergoes a reversal about midway. This is shown to be due to the introduction of an axial twist of 90°, which changes the direction of the fibers, so that for a short distance they come to lie nearly parallel with the long axis of the tuft, and at the same time the twist brings into view the other, the minor, axial aspect of the elliptical fibers. It is then fol-

[1] SCIENCE, May 1, 1931; January 13, 1933; March 7, 1933; June 16, 1933; July 21, 1933; October 20, 1933; November 17, 1933.

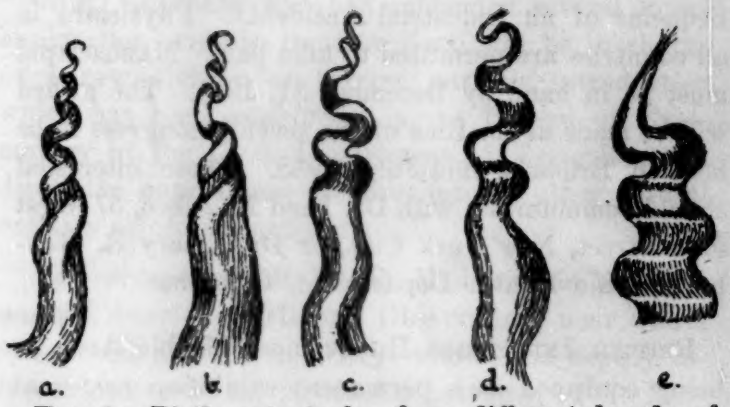

FIG. 1. Birth-coat staples from different breeds of sheep. a, b. South Devon, 5 months' lamb; c, d. Border Leicester, 3 months' lamb; e. Welsh Mountain, new-born lamb.

lowed by another axial twist of 90°, which directs the fibers into a normal spiral again, but with the rotation in a reverse direction, and bringing the major axial aspect into view. In a further type, Fig. 1c, the fibers are spiral above, but do not revert to the spiral below the first reverse; rather, they continue as a series of reversals one below the other on opposite sides of the staple, though usually in different planes. Finally, as in Figs. 1d and 1e, the initial spirality is wanting, and the whole staple consists of a periodic succession of reversals, first on one side and then on the other, though in planes varying in their inclination to one another. The appearance is that of a spiral flattened at different angles along its vertical axis. When the individual fibers of the staple are isolated they present a succession of angular or rounded waves, the so-called crimps, the characteristics of which are of high significance in wool estimations.

The manner of formation of the crimps is a subject of much dispute; but from the above it is manifest that they are to be interpreted as a periodic series of fiber reversals based on a fundamental spirality. By means of the Fiber Rotator, Rossouw[2] has shown that each crest or trough represents a separate reverse and a twist of 180°. This applies in the case of the narrow rounded crests and troughs of the Merino; but where the crests and troughs are broad and angular, as in Figs. 1c and 1d, a twist of 90° occurs at each angle, separated by a longer or shorter fiber interval.

The birth-coat tufts provide an interpretation of the great diversity of form in the later wool growth of the many different breeds of sheep. In such breeds as the Wensleydale and Dartmoor, and in the Angora goat, the staples remain more or less distinct from one another as long curly locks, and retain throughout the original spirality of the foetal coat, with reversals here and there along their length. In the luster breeds, Lincoln and Leicester, the distal part of the staples is largely free and regularly spiral, while the proximal is flattened and in the form of broad reversals, as in Fig. 1e, individual fibers appearing as a succession of wide rounded crimps, strongly inclined to spirality. The fleece of the Merino is compact, but divisible throughout its height into flattened staples, and is the most regularly and finely crimped of all wools. The crimping appears almost uniplanar, alternately right and left, but on close examination is found to approximate in varying degrees to the spiral form; this is especially the case in individual fibers when drawn out singly, and allowed to express their true form, free from any interactions from the other constituents of the staple.

The regular periodicity in the crimping of adjacent fibers permits of their aggregation into distinct groups or staples, in which condition the individual fibers assume a degree of parallelism. But in some breeds no regularity obtains as regards spirality, nor as to the form and occurrence of the crimps; adjacent fibers do not then "fit into" one another, and no stapling takes place. In these cases the fibers interlace with one another, and form an irregular, entangled growth, such as is well seen in the lower part of the fleece of the Mountain Breeds.

The wide distribution of spirality throughout organic nature tends to support the view that it is due to something foundational in organized matter. This is strongly emphasized by Professor W. Seifriz in his article in SCIENCE for October 20, 1933, "More about the Spiral Habit," where he concludes "that the spiral habit, whether in trees, snails or chromosomes, is a fundamental heritable protoplasmic quality." On the other hand, most workers have attempted a specific interpretation for particular occurrences. Thus as regards spirality and crimp in wool Dr. S. G. Barker[3] has advanced a physico-chemical interpretation. Postulating two simple harmonic forces acting at right angles to each other in the follicle, he shows how all the variety of form assumed by wool fibers can be explained. Dr. J. E. Nichols,[4] following suggestions as to differential growth gradients put forth by Professor W. D'Arcy Thompson[5] and Professor Julian Huxley,[6] considers that similar systems may operate within the comparatively restricted growth zones of hair follicles: "It is conceivable that the forces within the follicle required to give rise to the various curved forms of fiber may follow upon dif-

[2] S. D. Rossouw, "A Preliminary Study on the Relationship between Crimp and Contour in Wool Fibers," *Jour. Text. Inst.*, 22: T375, 1931.

[3] S. G. Barker, "The Physical Significance of Crimp or Waviness in the Wool Fiber," *Trans. Faraday Soc.*, 29: 239, 1933.

[4] J. E. Nichols, "Origin of Curls and Twists in Wool Fibers," *Nature*, January 11, 1933.

[5] "Growth and Form," 1917.

[6] "Problems of Relative Growth," 1932.

ferent growth intensities . . . while the disposition and orientation of the follicle in relation to the general growth gradients would affect the direction and magnitude of the forces at play."

It will be admitted that much yet remains to be gained before a complete understanding of the spiral habit is forthcoming, in both its general and particular manifestations. That the crimping of wool represents a periodicity of reversals of rotation, due to a like succession of twists on a fundamental spirality, by no means suggests a simplicity in nature's methods.

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THE TIME CONSTANT

SERIOUS misinformation regarding inductive circuits, contained in a recently published text-book on college physics, appears to justify my calling attention to the facts of the case.

In a circuit containing electromotive force, resistance and inductance the fundamental equation

$$e = ri + l\frac{di}{dt}$$

leads to the Helmholtz equation

$$i = \frac{e}{r}\left(1 - \epsilon^{-\frac{r}{l}t}\right) = i_o\left(1 - \epsilon^{-\frac{r}{l}t}\right)$$

i being the value of the current at the end of t seconds, and i_o the final value. From this it follows that the rate of rise of the current,

$$\frac{di}{dt} = \frac{r}{l} i_o \epsilon^{-\frac{r}{l}t} = \frac{r}{l}\left(i_o - i\right)$$

At the very start, at the moment the circuit is closed, and before the current has an assignable value, we may say $i = o$, and hence at the start

$$\frac{di}{dt} = \frac{r}{l} i_o.$$

Evidently, if this rate of increase should be maintained for $\frac{l}{r}$ seconds the current would reach its final value i_o. This ratio $\frac{l}{r}$, generally called the time constant, is therefore numerically equal to the number of seconds required for the current in reaching its final value if the initial rate of rise should be maintained. This way of regarding the time constant I do not find in any of my books, but I have found it helpful in my teaching experience. Obviously, with a fixed inductance and a fixed ratio between e and r so that i_o is fixed, the rate of rise of current increases as r increases. The curves in the text-book referred to teach exactly the reverse of this truth.

Similarly, in a circuit containing electromotive force, resistance and capacity the fundamental equation

$$e = ri + \frac{q}{c},$$

q being the charge in the condenser of capacity c, leads to the charge q at the end of t seconds

$$q = q_o\left(1 - \epsilon^{-\frac{t}{cr}}\right),$$

q_o being the final charge.

The rate of increase of q, in other words the current flowing into the condenser, is

$$\frac{dq}{dt} = \frac{q_o}{cr}\epsilon^{-\frac{t}{cr}}$$

which becomes $\frac{q_o}{cr}$ at the very start when $t = o$. Obviously, this rate of charging, if continued for cr seconds, would give the condenser its final maximum charge q_o. So here the time constant cr may be defined numerically as the number of seconds in which the condenser would receive its final charge, in case the initial rate of charging should be maintained.

The accurate calculation and plotting of the growth of current in an inductive circuit is rather laborious, but an approximate graph may be easily and rapidly plotted by a method given by C. V. Drysdale in his "Foundations of Alternating Current Theory."

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"'GUNS' OF SENECA LAKE"

"SILENCING the 'Guns' of Seneca Lake" was the title of a discussion which appeared in SCIENCE for April 13, (page 340), having been communicated by Professor Herman L. Fairchild, of the University of Rochester. In it Professor Fairchild offered an explanation of a mystery of sound which, as he states, "has hovered over Seneca Lake, in central New York, for more than a century." This is what is known by the local residents as the "lake guns," an occasional low, dull boom suggesting a distant muffled explosion.

The explanation offered in Professor Fairchild's communication was that Seneca Lake occupies the upper part of a glacially deepened valley which cuts the Oriskany Sandstone at a depth of about 1,450 feet below the surface of the lake, and that the "lake guns" are caused by volumes of natural gas which escape from that porous gas-bearing stratum, find their way upward through the 450 feet of superincumbent glacial drift and ascend rapidly through the

600 feet of lake water above it, exploding at the surface. He states that these "guns" have now suddenly ceased, "with no sound reported for the last summer," and that they are probably silenced forever. The interpretation given is that the many gas wells which have recently been drilled in the Wayne-Dundee field not far from Seneca Lake have diminished the gas pressure in the Oriskany, so that the gas no longer escapes into the lake.

This hypothesis is ingenious and at least plausible on the evidence presented, but the purpose of the present communication is to state that Professor Fairchild's obituary of the "guns" comes before their demise, for the writer heard these sounds as recently as last October.

During many years the lake "guns" were heard on innumerable occasions when the writer lived adjacent to Seneca Lake and, as a youth, spent month in and month out on it and in it, camping, swimming, sailing, boating and fishing. Each autumn at the present time he returns to the same scene for a vacation, and this is spent in a way which should bring to notice most of the audible lake sounds; that is, in working alone from morning till night laying stone masonry on a rock cabin situated actually in the lake waters, at the base of a cliff (which may incidentally be instrumental in concentrating sounds which proceed across the lake). This is at Glenora, close to the Dundee gas field, and it was from there that the "guns" were heard last October. The previous absence of reported observations of lake "guns" in 1934 may have been due to the fact that it is the fishermen who most frequently report them, and that last autumn the bass fishing was so poor that relatively few fished.

In itself the hypothesis of escaping gas bubbles is not new, having been commonly current among the native residents of Seneca's shores for many decades, but its association with the depletion of the nearby gas fields, credited by Professor Fairchild to Mr. A. M. Beebee, geologist of the Rochester Gas and Electric Corporation, is a new and ingenious hypothesis which probably will acquire standing if the lake "guns" actually become silent later on.

Interested readers will find in Davison's "Manual of Seismology" a discussion of phenomena of a similar description, under the section "brontides." "Guns" are evidently heard in several localities—Italy, the Philippines, Africa, Haiti, Belgium—though their cause is unknown. Those heard at Seneca Lake seem to be most frequent in the autumn and in the daytime —in fact, the writer has never heard them after dark. Their direction is vague, and like the foot of a rainbow, they are always "somewhere else" when the observer moves to the locality from which they first seemed to come. No large bubbles or volumes of gas have actually been observed broaching on the surface of the lake, but is it not probable that a large single volume of gas, starting from the bottom of the waters 600 feet below, would be broken up into very many small bubbles during its upward passage through that amount of water? Theoretically, this should not occur, but actually, due to some form of instability, it possibly would.

Finally, is it not likely that gas from the Oriskany, seeping upward through the 450 feet of drift between that horizon and the top of the drift filling, would be stopped and held temporarily by the layers of fine compact lake-bottom clay which have accumulated there since the recession of the Wisconsin ice; and then, when a sufficient volume of gas had thus become pocketed under the clay (perhaps in a large "blister"), the latter would suddenly give way and cause the explosion, not at the surface, but at the bottom of the lake. The sound would then be transmitted upward from the bottom by the water, emerging with the vague non-directional origin so often noted in connection with the phenomenon heard.

Since the above was written, Mr. E. R. Dobbin, of Geneva, N. Y., has stated in *The Syracuse Herald* (April 25) that at Kashong, near Dresden, N. Y., the Seneca Lake guns "were quite as distinct last summer as formerly, perhaps not so frequent. They have also been heard quite distinctly this spring . . . the Seneca Lake guns," he adds, "are still in existence."

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NEW YORK, N. Y.

NUTRIENT MEDIA WITH STABLE HYDROGEN-ION CONCENTRATION

PROFESSOR SAM F. TRELEASE and Helen M. Trelease in a recent issue of SCIENCE[1] emphasized the fact that one of the important problems in the culture of higher plants in artificial media is that of maintaining the hydrogen-ion concentration of the culture solution within limits favorable to growth. They propose for this purpose the use of physiologically balanced solutions. It is not possible to judge their very interesting idea from the contents of their short note.

In writing this note I should like to draw attention to my work, covering a period of over ten years, which has dealt with this question. The results of this work have appeared in several publications and have been fully described in recent papers.[2]

I take this opportunity to give a very brief summary of my studies. These investigations showed that the slightly soluble phosphates plus NH_4NO_3 are

[1] SCIENCE, 78: 438–439, 1933.

[2] "Nutrition artificielle des plantes cultivées. I. Mélanges nutritifs à pH stable," *Annales Agron.*, Paris, 2: 809–853, 1932; 3: 53–72, 1933.

efficient in stabilizing the reaction in acid media. A study of the buffer capacity of different slightly soluble phosphates[3] showed that $Mg_3(PO_4)_2 \cdot 22H_2O$ can be used for alkaline media. As a result of an x-ray study[4] of these phosphates it was possible to show how to prepare and use them. These experiments enabled me to develop four nutrient mixtures:[5] (1) acid, pH 4.9–5.5; (2) slightly acid, pH 5.5–6.8; (3) neutral, pH 6.9–7.3; (4) alkaline, pH 7.5–8.0.

It is unnecessary to give further details of the work, which has already been published in complete form. I take this opportunity to emphasize once more that the details of the technique of my culture methods (including the aeration of the media to provide the roots with oxygen, the preparation of the salts, etc.) are of fundamental importance. These are fully described in my papers.

In my next work I shall discuss my experiments concerning the rôle of Mn, Si, I, Zn, Al, B, Cu, Li, Na, As, Ni, Co, etc., in mixtures of stable pH value.

CH. ZINZADZÉ

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(temporarily)
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A RICH SOURCE OF β-CAROTENE

THE difficulty in separating the different carotenes and the danger of oxidation with increased handling have emphasized the desirability of working, where possible, with a source having only one form present. Since many of the richer sources contain mixtures of the two forms, it may be of interest to those working with the carotenes to know that the Perfection pimiento is a rich source of β-carotene, apparently free of α-carotene.

It has been shown[1] that with antimony trichloride α-carotene shows an absorption band at 542 mμ and β-carotene shows an absorption band at 590 mμ.

Using this method and the method of Zechmeister and Cholnoky[2] for the quantitative determination of carotene, dried pimiento shells were found to contain from 200 to 665 mg of β-carotene per kilogram. The quality of the fresh material and the method of preparation have considerable influence on the amount of carotene present in the dried product.

W. L. BROWN

GEORGIA EXPERIMENT STATION

WHAT IS A LOCUST?

ONE of the outstanding difficulties in teaching elementary entomology is the confusion concerning the word "locust." The so-called seventeen-year locust is of course a cicada, belonging to a totally different order from the true locusts. No doubt all teachers of entomology stress this point, but in the "Handbook for Boys," issued by the Boy Scouts of America, of which it appears that 4,792,871 copies have been printed, there is (p. 483) a picture of a cicada, labelled "Locust," without any qualification. This appears in an article by Dr. L. O. Howard, but as the text does not refer to this insect I infer that the illustration was added by the editor. Thus the popular error is reinforced on apparently good authority. Every effort should be made to substitute the unobjectionable term "cicada."

T. D. A. COCKERELL

UNIVERSITY OF COLORADO

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MINUTES OF THE EXECUTIVE COMMITTEE

THE executive committee of the association held its spring meeting in New York City on April 15. By courtesy of the chairman the sessions were held in the office of the Science Press, Grand Central Terminal.

The meeting was called to order at 10 A. M. by the chairman with the following members of the committee present: Cattell (*chairman*), Compton, Conklin, Curtiss, Fox, Livingston, Thorndike, Ward, Wilson, Woods. Dr. Hildebrand was unable to attend. Formal sessions were held morning and afternoon, and following the evening dinner discussion was continued until 10 P. M.

(1) The permanent secretary reported on the proposed project for aiding unemployed scientists through government funds for emergency relief. Under the reorganization of the C.W.A. relief funds are distributed to the states. While provision is made for research projects under state relief commissions, no place was found in government organization for a national project. A communication is to be sent out from the permanent secretary's office advising all correspondents concerning the present situation.

(2) In response to a request for approval of a special measure now before Congress to provide fellowships for unemployed scientists the permanent secretary was advised to call attention to the Science

[3] *Comptes rend. Acad. Sci. Paris*, 194: 1924–1927, 1932.
[4] "Phosphorsäure," Berlin, 3: 279–297, 1933.
[5] The term "nutrient mixture" has been found preferable to "nutrient solution." The reason for this choice is fully explained in the publication cited above.

[1] Karrer, Walker, Schopp and Morf, *Nature*, 132: 16, 1933.
[2] *Ann.*, 455: 70, 1927.

Advisory Board appointed by President Roosevelt as being the proper agency to pass upon proposals.

(3) The mimeographed semi-annual report of the permanent secretary embracing data on finances, membership and other activities was presented and discussed.

(4) The permanent secretary was authorized to order not less than 4,000 copies of the new Summarized Proceedings volume.

(5) It was voted to present to the council for discussion at Pittsburgh an amendment to the constitution to provide for increasing the membership dues from $5 per annum to $6 or more per annum. (An amendment to the constitution requires unanimous vote at a general session of the association or a majority vote at two consecutive *annual meetings*.)

(6) Since it seemed that immediate provision might need to be made for increasing current income, it was proposed that payments be temporarily fixed by the council and that statements of dues for 1935 be printed as follows:

Dues for 1935	$5
Emergency	1
	$6

Final action was deferred and the topic made a special order of business for the Berkeley meeting of the council.

(7) The method of balloting for president and section officers was approved as formulated on a form submitted. That form was substantially like the form used last year.

(8) The Fidelity bond covering the permanent secretary and the executive assistant was approved, and the auditor, W. J. Humphreys, was authorized to sign the accountability certificate.

(9) Election of fellows was approved as follows: Section F, 1; Section L, 1; Section N, 1; Section Q, 74; total, 77.

(10) The National Council of Teachers of Mathematics was invited to participate in the Pittsburgh meeting next December.

(11) The Society for Research on Meteorites was invited to participate in the Berkeley meeting.

(12) It was voted that the permanent secretary should arrange for a Maiben lecture for the Berkeley meeting.

(13) After reporting plans for the Pittsburgh meeting in December, 1934, the permanent secretary called attention to the evident crowding of the meeting, since many societies plan to hold sessions on Thursday, Friday and Saturday, leaving the last half of the meeting with few features. The local committee has plans for the entertainment of visiting scientists on Sunday, and this may remedy the situation.

(14) It was voted to contribute one half, and not to exceed $100, of the expenses of the Biological Smoker, generally scheduled for the winter meeting.

(15) The general secretary was authorized to correspond with the secretary of the American Society of Naturalists regarding the association's participation in the Biological Smoker and to make general arrangements for this event.

(16) It was voted to contribute one half, and not to exceed $100, of the expenses of a smoker to be arranged for engineers, physicists, geologists, chemists and mathematicians at the Pittsburgh meeting.

(17) Dr. Compton was asked to confer with the secretary of the Engineering Section (M), Dean V. Bush, regarding a smoker for engineers with physicists, geologists, chemists and mathematicians or others, at the winter meeting and to work out the general arrangements.

(18) It was voted to approve the Phi Beta Kappa lecture scheduled for the Pittsburgh meeting in accord with the plan of the secretary of that society and with plans of the Section on Social and Economic Sciences and the Section on Historical and Philological Sciences for their meetings.

(19) It was proposed that election of officers at Pittsburgh be made a special order of business for the council on Monday morning, December 31, 1934.

(20) The meeting now tentatively scheduled for Rochester, New York, in the summer of 1936 was definitely fixed for that place and date.

(21) The office of the permanent secretary was asked to make a study of available meeting facilities in Washington in connection with the meeting scheduled for December, 1936.

(22) The permanent secretary was authorized to publish promptly the dates of the Rochester and Washington meetings and to inform the secretaries of the councils of the social and economic science societies and of the learned societies of the exact dates selected.

(23) A communication from Dr. Duren J. H. Ward, Denver, extended an invitation to members of the executive committee to stop in Denver *en route* to the Berkeley meeting for the purpose of investigating the facilities for a meeting in that city, now tentatively set for the summer of 1937, and to learn more about the organization of the Far-Reaching Foundation. The executive committee expressed its deep regret that the invitation could not be accepted.

(24) A report from the committee on the place of science in education was accepted and ordered filed.

(25) It was voted that the chairman of the executive committee arrange for a statement expressing appreciation of the association for the participation of Dr. W. M. Davis (deceased) in the Boston meeting and in particular as the Maiben lecturer. Details concerning publication and use of the statement were entrusted to the chairman.

(26) A report previously presented at the Boston meeting was read from the committee on grants, making recommendations regarding the use of the association's funds for research. The executive committee adopted the recommendation that grants in aid of research should be continued as in the past.

(27) The following were elected members of the committee on grants to succeed those whose terms had been completed:

Arthur H. Compton (1937) (for Physics), *chairman;* University of Chicago.
C. C. Little (1937) (for Zoology), Jackson Memorial Laboratory.
Edward W. Berry (1936) (for Geology), Johns Hopkins University.
Walter R. Miles (1936) (for Psychology), Yale University.

(28) Upon recommendation of the committee on Grants, the executive committee voted the following grants to be paid out of available funds of the treasurer:

F. C. Brackett, 11 Woodbine Street, Chevy Chase, Md.	$ 500
B. M. Duggar, University of Wisconsin, Madison, Wis.	420
J. C. Stearns, University of Denver, Denver, Colo.	250
	$1,170

(29) The executive committee voted the following grants, to be paid out of available funds of the treasurer, with the specific stipulation that these payments carry no obligation for the future:

Mt. Desert Laboratory	$100
Concilium Bibliographicum	100
American Mathematical Society	100

(30) It was suggested that an index of members, arranged by cities and states, be added to the new volume of Summarized Proceedings. This matter was left to the discretion of the chairman and permanent secretary with power.

(31) Dr. Arthur H. Compton was appointed the representative of the association at the Aberdeen meeting of the British Association for the Advancement of Science.

(32) The permanent secretary reported on a meeting of the American Council on Education held in Washington last February and was authorized to act as the association's representative at future meetings of the council.

(33) Dr. A. F. Woods was appointed as representative of the Section on Agriculture (O) on the Board of the Union of American Biological Societies, to take the place of Roscoe W. Thatcher, deceased.

(34) Resolutions were presented from the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, dealing with the curtailment of the scientific work at the Bureau of Standards. After discussion, the following resolutions were adopted:

WHEREAS, The American Association for the Advancement of Science, comprising with affiliated American scientific societies a membership of a quarter of a million, exists because its members are convinced of the importance to America of the advancement of science and its useful applications in this country;

WHEREAS, The Bureau of Standards plays an essential and unique rôle in supplying American scientists with technical data and methods concerned with materials, measurements and standards which are essential to the progress of science and not otherwise available;

WHEREAS, This and other scientific bureaus of the Federal Government represent a great capital investment of money, work and scientifically trained men, as well as a prolific source of those elements essential to the national prosperity and welfare of the future;

WHEREAS, The permanent importance to this country of the continued work of the scientific bureaus maintained by the Federal Government is relatively far greater than is implied by the half of one per cent. of the Federal budget allotted to these scientific bureaus;

WHEREAS, The recent cuts in appropriation to these bureaus have crippled their work and disorganized their staffs so seriously as to impair their service and in large measure destroy that capital investment of money, work and men on which the future technical progress of the country depends; and

WHEREAS, A large part of the budgetary savings effected by these curtailments are false economies in that: (1) the investment in some earlier work is lost; (2) some essential work is continued in a less efficient manner; (3) many former members of staffs of these bureaus are now maintained at government expense on emergency Federal projects of far less value and with far lower efficiency than that of the work from which they were dropped in the economy program; and (4) the technical effectiveness of the country is receiving a blow from which it will take years at best to recover; therefore be it

Resolved, That the attention of those responsible for the administration of Federal affairs be called to these unfortunate aspects of the present situation in the scientific bureaus of the Government, and that they be requested to provide adequately for the continuation of such scientific work as is, in the opinion of qualified scientists and technical experts, essential to the national prosperity and not capable of or appropriate for efficient continuation by non-governmental agencies; and be it further

Resolved, That copies of this resolution be sent to the President of the United States, to the members of his Cabinet, to the Director of the Budget and to members of Congress, and that it be published in the official organ of this association.

(35) A communication from Dr. J. C. Merriam regarding adult education was presented. After discussion a committee was appointed to consider the subject and to make a survey of possibilities for the A. A. A. S. to develop this work. The committee appointed is as follows: Harlow Shapley, *chairman*, W. H. Howell, C. C. Little, John C. Merriam and Wm. F. Ogburn. It was suggested that this committee consider the manner of cooperating with other organizations and co-opt other members or if desired form subcommittees to study special topics in order to report in October.

HENRY B. WARD,
Permanent Secretary

THE NATIONAL ACADEMY OF SCIENCES. IV

The velocity-distance relation for isolated extra-galactic nebulae: EDWIN HUBBLE and MILTON L. HUMASON. The velocity-distance relation, $\log v = 0.2m + 0.706$, derived from 85 isolated nebulae, parallels that derived from clusters, but is displaced toward the brighter side by about one magnitude. The displacement is interpreted as an effect of selecting the nebulae on the basis of apparent magnitude. Since the luminosity function approximates a normal error curve with a maximum at M_o and the density function is constant, the frequency distribution of M for a given m will be another normal error curve with the same dispersion but with the maximum displaced by $M_o - \overline{M} = 1.386^2$. The observed displacement represents a dispersion of the order of 0.85 mag., in close agreement with observed dispersion, 0.86 mag., of the residuals. Isolated nebulae and cluster members give the same velocity-distance relation and hence are strictly comparable objects. M_o may be estimated from the Virgo cluster, where stars are found in some of the nebulae. The data as yet indicate no significant revision of the value previously derived, $M_o = -13.8$.

Loudness and pitch of musical tones and their relation to the intensity and frequency: H. FLETCHER (introduced by F. B. Jewett). Loudness and pitch are psychological terms which are used to describe sensations produced when certain types of waves operate upon the hearing mechanism. Intensity and frequency are the corresponding terms to describe the physical quantities power transferred per unit area and vibrations per second executed by the sound wave. The relation between these psychological and physical aspects of a musical tone has been investigated using a group of typical listeners. Precise scales were invented and used for representing the sensations of loudness and pitch. In comparing loudness a pure tone having a frequency of 1,000 cycles per second and with intensity variable throughout the audible range was used as a reference tone. In comparing pitch, a pure tone having a constant loudness and with frequency variable throughout the audible range was used as a reference tone. Typical results follow: A 50-cycle tone with an intensity which is 10,000 times that at the threshold of hearing produces the same loudness as a 1,000 cycle tone with an intensity which is 1,000,000,000 times its threshold value. The intensity of a complex tone with ten components all equal in intensity but different in frequency is ten times that of each component, as is well known. On the other hand, the loudness of one such complex tone with frequencies which are harmonics of 500 cycles per second was found to be equal to that of the 1,000 cycle component raised one thousand times rather than ten times in intensity. An observer's location of the pitch was found to depend upon the intensity as well as the frequency. For example, the pitch of a 200-cycle tone was located at a position which was as much as one quarter of an octave lower at the very high intensities than at the low intensities. For pure tones having frequencies near 2,000 or 3,000 cycles per second, no difference of pitch was observed as the intensity was changed. Similar small pitch changes were observed with complex tones. Some very large changes were observed with particular changes in the components. For example, the pitch of a complex tone having four components of equal intensity, but with frequencies of 400, 600, 800 and 1,000 cycles per second was perceived as that corresponding to a 200-cycle tone. If to this complex tone, three additional components having frequencies 500, 700 and 900 cycles per second, are added, then the pitch will be perceived as an octave lower or that corresponding to a 100-cycle tone.

The realm of the nebulae: EDWIN HUBBLE. The observable region—the region of space that can be explored with existing telescopes—is a vast sphere through which a hundred million nebulae are scattered at average intervals of the order of a million light years. Each nebula is a stellar system comparable with our own system of the Milky Way. If the observable region is a fair sample, we may hope to infer the nature of the universe from the observed characteristics of the sample. Two general characteristics have been established in the past five years. The large scale distribution of nebulae is uniform, since counts of nebulae behave as random samples of a homogeneous population. Light from the nebulae is reddened in direct proportion to the distance it has traveled. These data, together with the general laws of nature, permit certain inferences concerning the universe which are embodied in the current theories of cosmology.

African rift valleys: BAILEY WILLIS. African rift valleys have been interpreted as cracks due to tension produced by collapse of the hypothetical Gondwana Continent. They are found to be effects of unequal elevation, combined with local compression with or without extrusion of lavas. Theoretical discussion involves problems of general application to elevation subsidence and mountain building.

Isostasy and the eruptive crust: BAILEY WILLIS. Isostasy and eruptive crust are related as effect and cause. The argument is that the existing crust of the

earth is altogether eruptive and its features are logical results of the ordinary processes. The notion of an original crust is discounted and material divergences from current ideas are indicated.

Lightning and the development of its discharge: B. F. J. SCHONLAND (by invitation). An account is given of further photographic studies of the lightning discharge, using an improved form of Boys camera with two fast-moving, one slow-moving and one fixed lens. It has been shown previously that the majority of lightning strokes examined were double and consisted of a downward-moving dart-like leader-stroke, followed immediately upon arrival at the ground by a more intense flame-like upward-moving main stroke. Examination of 75 flashes by improved methods has now shown that this combination of leader and main stroke is general. The leader which blazes the trail for the first of a series of lightning strokes along the same path is, however, of a different character to the others, for the luminous track does not pass rapidly downward but pauses on its way after completing each new length of 50–100 meters (stepped leaders). These stepped leaders are found to split on their way, blazing downwardly directed branches, which are subsequently more brilliantly illuminated by the upward-moving main discharge. In a number of cases the most brilliant part of the subsequent discharge is not from ground to cloud but from ground to one or more of the branches. It is suggested that the leader stroke carries down into the air as an electron avalanche the major portion of the cloud charge. The stepped leaders pause for times of the order of 10^{-4} second, and would thus give rise to radiation on a wave-length of about 30 kilometers, an effect which may play some part in the formation of the ripple in atmospherics. The work was carried out in conjunction with H. Collens and D. J. Malan and under the auspices of the South African Institute of Electrical Engineers.

Aluminizing process for coating telescope mirrors: JOHN STRONG (introduced by R. A. Millikan). A steel bell jar 40″ in diameter is evacuated by apiezon oil diffusion pumps and a Hypervac pump to 10^{-4} mm of mercury pressure. Aluminum is distilled from twelve tungsten coils to form a uniform film 1/10 μ in thickness on the surface of the telescope mirror. The mirror surface is made clean for the coating process by an electrical discharge as the bell jar is being evacuated. The evaporated aluminum coat is immune to tarnish, adheres tenaciously to the glass and is not easily scratched once the oxide film, which forms on it, is established. The reflectivity is 89 per cent. in the visible, dropping gradually to 80 per cent. at 2500 Å. Measurements at Lick Observatory show the reflectivity, for photographic light exceeds silver by approximately 50 per cent. Stellar spectra to 3000 Å have been obtained.

Pure rotation spectrum of the HCl flame: JOHN STRONG (introduced by R. A. Millikan). Pure rotation lines for j = 17 to 33 of the emission spectrum of the HCl flame are measured with a KBr prism. The following empirical formulae are determined to represent two series of lines measured corresponding to pure rotation in the two lowest oscillation states:

$$N = 0, \quad \nu = 20.9\ j - .00185\ j^3$$
$$N = 1, \quad \nu = 20.2\ j - .00163\ j^3$$

The linear coefficients agree satisfactorily with values calculated from the empirical oscillation-rotation formula. Theoretically the two cubic coefficients should be equal. High values of j allow considerable accuracy to be ascribed to these cubic coefficients, so the discrepancy is not regarded as accountable by experimental error.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE PLACE OF PHONOPHOTOGRAPHY IN THE STUDY OF PRIMITIVE MUSIC

THE purpose of this note is to illustrate an up-to-date method of recording, transcribing and interpreting primitive music.[1] The relatively original features are the use of the graphic method of phonophotography and the transcription of songs in the pattern score. The original materials may be collected by the improved phonographic field equipment and, in increasing amount, by the newer methods of sound film production. In some instances the phonophotographic apparatus itself can be taken into the field. In the laboratory the phonophotograms will be made from the sound recordings. From a single playing before the microphone three groups of records are made: First, a re-recording of the song on hard disks for auditory reference; second, a phonophotographic record of pitch, intensity and time; and, third, an oscillogram for harmonic analysis to determine tone quality.

Fig. 1 presents in pattern score a song by a woman singer of the Sioux tribe, who exhibited at the Century of Progress. The record was taken to the Iowa Laboratory for graphic analysis through the kindness of Miss Frances Densmore, who in turn acknowledges her obligations to Dr. George Herzog for recording by the Fairchild aluminum disk recorder. The present note deals only with the technique of graphical recording; the musical interpretation of this particular record is left to Miss Densmore and indeed to any student of primitive music who will give the time to draw upon the resources here presented when dealing with any specific issue.

In this score the upper curve of each section represents pitch and the lower is a graph of intensity,

[1] See Metfessel's "Phonophotography in Folk Music," University of North Carolina Press, 1928, and various authors, "Studies in the Psychology of Music," Vol. I, University of Iowa, 1932.

both on a time scale. Pitch is indicated at the left by identification of certain lines in the musical scale and intensity by numbers denoting decibels. Each horizontal space represents a semi-tone for pitch and four decibels for intensity, zero being taken arbitrarily as approximately the level of the weakest

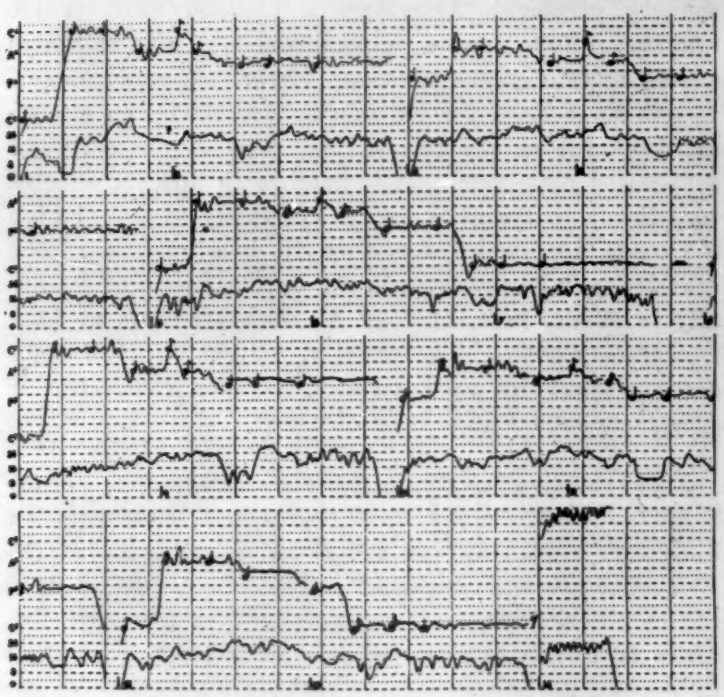

FIG. 1

tone in the song. The vertical bars denote seconds, which are subdivided into tenths of a second by dashes and spaces. Each tone is represented by a graph tracing the tone movement in exact detail. The conventional notation is interpolated merely as a guide to persons not accustomed to reading this type of record, and illustrates to some extent the limitations of conventional musical notation.

The pitch graph is a faithful record of all the characteristics of pitch intonation in the entire song. It gives the melody and reveals all types of pitch variation in the sustained tones, transitions, attacks and releases. It measures tonal intervals and shows what relation the singing has to scale systems. It shows the character of the phrasing. One is struck at once with the futility of trying to convey an adequate description of the pitch performance in terms of the conventional musical notation as based on auditory transcription. The presence of a fairly normal and beautiful vibrato is confirmed and quantified as to extent and rate. Other tonal ornaments allied to those discussed by Metfessel in Negro singing are shown in certain characteristic flights and dips. Apart from irregularity and lack of rigidity, the deviations from recognized tonal intervals are matters of great interest. The whole tonal movement reveals the characteristic abandon in the legato style which calls for interpretation into musical significance.

The intervention of the phonograph record between the original singer and the photograph in this case introduces certain well-recognized errors, but relatively the dynamic relationships are recorded significantly. Here one sees all the varieties of increase and decrease in loudness from moment to moment, the divisions of measure, meter and rhythm, numerous devices for ornamentation and, of course, many manifest faults. It is of great value to be able to see the tonal, dynamic and temporal aspects in the same picture in an integrated situation.

In the pattern score we have a source of information from which to determine the tempo, time variations, measure formation, rhythm and phrasing of the song. Since pitch and intensity are plotted against time, the interrelationships can be studied more easily. Finer time measurements can be made from the original phonophotogram, which is on a larger scale.

The fourth factor, timbre, is of such vast intricacy that it does not lend itself to complete record in the pattern score. One may, however, select any number of samples at strategic points in the oscillogram and show the spectrum which results from harmonic analysis of the form of the wave. Of course a true sound spectrum can be made only from the original source of sound. Where an adequate oscillogram is obtainable, it is now clearly possible to preserve and describe the exact quality of the tone in quantitative terms. For some less exacting studies, harmonic analysis of sound waves from extra high-grade recordings will be profitable.

Where words are present, a phonetic transcription should, of course, be inserted into the pattern score. This song had no discrete words. Field notes and other accessory data should be supplied according to current methods of musical anthropology.

Thus we may have in these four elements of tone an adequate record in permanent objective form. But, it is asked, what of the feeling, the interpretation, the esthetic appeal and all that is precious to the musician? The answer is that it is all there, because everything that is conveyed from the singer to the listener, whether it be information, emotion or a drive to action, is expressed through these four media in the objective record and in none other. We have not yet felt the full impact of the principle that in the sound wave the intangibles of music are physically tangible.

It is possible that many of the wax recordings stored in the ethnological archives can be redeemed for further value by the principles herein discussed. Many of them are fairly adequate with respect to pitch and time; intensity and tone quality factors would have to be omitted from such study.

With the improved techniques of field recording and of laboratory study it is of course desirable that in all future collecting only adequate and permanent recordings should be made. The limitations of transcription by hearing have been pointed out clearly by the phonophotographic analysis.

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SPECIAL ARTICLES

A LETHAL DWARF MUTATION IN THE RABBIT WITH STIGMATA OF ENDOCRINE ABNORMALITY

RECESSIVE dwarf mutations in the guinea pig and in the mouse have been described by Sollas[1] and by Snell,[2] respectively. Both of these mutants are viable, and carriers of the dwarf genes appear to be normal. The skeletal changes in the guinea pig suggest an achondroplastic dwarf, while according to Smith and MacDowell[3] the dwarf character in the mouse is due to a hereditary deficiency of the growth-promoting hormone of the pituitary.

Abnormally small or dwarf-like individuals are of frequent occurrence in the rabbit as familial characters but, as a rule, affected animals show no serious impairment of vitality or any other decided abnormality. A dwarf mutation has been encountered, however, among the progeny of a Polish rabbit which is of interest from the point of view of size inheritance, on the one hand, and the occurrence of pathological conditions in animals possessing the dwarf gene, on the other. This mutation appeared in the course of experiments which were being carried out for other purposes and the nature of the abnormality has not been determined with certainty, but the evidence obtained so far indicates that the condition is of endocrine and probably of pituitary origin.

The original male transmitting the dwarf gene has been mated with related and unrelated Polish females and with numerous unrelated females of various breeds. From the F_1 progeny thus obtained, F_2 and back-cross litters have been produced.

An analysis of birth weights shows that the F_1 progeny is divisible into a large and a small class of equal numbers (55 small, 56 large). The actual weights of these animals are influenced by the relative weights of parental stocks, but in general the ratio of the small to the large class is 4:5. In two instances, typical dwarfs occurred in F_1 litters. The F_2 progeny contains individuals of three classes with a birth weight ratio of approximately 1:2:3. The same result is obtained when certain F_1 females are back-crossed to the original male parent, while with other females the litters are of the F_1 type. The actual weights obtained for 56 young derived from parents both of which were known to produce dwarfs were 13.66, 31.55 and 46.86 grams. The number in each class was 15, 26 and 15, respectively. A slight excess in the weights for classes 2 and 3 may be attributed to the fact that animals of these classes are frequently fed before weights can be obtained, while those of class 1 are not. No correction is made in the values given.

Individuals of class 1 are non-viable dwarfs. As far as we have been able to determine by test matings, those of class 2 are transmitters of the dwarf gene, while those of class 3 are homozygous normals. The F_1 progeny is composed of animals corresponding genetically with those of classes 2 and 3.

The dwarfs of this stock are born alive and occasionally they are capable of nursing, but so far, none of them has lived longer than a few days. They are delicately formed and to outward appearance are fully developed except for the bones of the calvarium, which, as a rule, are incompletely calcified.

Other classes of young are apparently normal at birth, but they are subject to numerous abnormalities in early life and to a peculiar process of deterioration after full sexual maturity has been attained. The most evident of the early abnormalities is an affection of the bones, which is characterized by the resorption of calcium with the production of cranial defects, spontaneous fractures of the long bones and deformities due to bending, which indicate increased fragility, on the one hand, and softening or osteomalacia, on the other. This condition develops during the first few weeks of life. At the onset, animals of this type are well nourished, or even fat and pudgy, but in time growth is diminished or completely arrested and they are extremely sluggish. Death is apt to occur at this stage. Vitamin treatment is of little or no avail, but rapid improvement follows fostering and there is some recent evidence that irradiation with the Mazda CX lamp is beneficial. Animals that recover are active and vigorous, but they present a dwarfed or stunted appearance; they are, for a time, pot-bellied and their legs are deformed and shortened. After maturity has been reached, a secondary deterioration occurs in many animals which is characterized by loss of weight (20.0 to 30.0 per cent.), softening and erosion of the teeth and reproductive disorders.

These peculiarities appear to be limited to carriers of the dwarf gene or are more pronounced in animals of this class than in their normal litter mates, but the

[1] I. B. J. Sollas, *Rep. Evol. Com. Royal Soc.*, 5: 51, 1909.
[2] G. D. Snell, *Proc. Nat. Acad. Sci.*, 15: 733, 1929.
[3] P. E. Smith and E. C. MacDowell, *Anat. Rec.*, 50: 85, 1931.

connection, if any, between the dwarfing factors and those responsible for other abnormalities has not been determined. It will be necessary to observe, mark, rear and test large numbers of animals before these points can be settled.

The observations made on this group of animals point to an incomplete recessive mutation, which is characterized by a dwarfing effect and by functional disorders in both heterozygous and homozygous individuals. The reduction in size is of a measured order so that a unit size factor becomes operative in the determination of the weights of affected individuals in relation to the weights of normal members of the population. The unit factor is represented by a homozygous, lethal dwarf which is one third the weight of its normal sibs and one half the weight of its heterozygous sibs. It is possible that factors operating in this manner may be concerned in other types of size inheritance.

The combination of abnormalities presented suggests a primary pituitary disorder which affects both the acidophilic and the basophilic elements of the anterior pituitary with secondary disturbances of other endocrine glands.[4] This possibility is further supported by the occurrence in another group of rabbits of a hereditary condition which simulates over-function of the acromegalic type. This will be reported in another paper.

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THE BIOLOGICAL AND CHEMICAL NOMENCLATURE FOR THE CAROTENOIDS

THE class of natural pigments known as carotenoids has attracted the attention of botanists, zoologists and chemists for nearly a century. The past decade has witnessed the nearly complete clarification of the chemical constitution and molecular configuration of almost all the known members of this class of substances. It is now definitely established that the true carotenoids, *i.e.*, those members which have the same number of carbon atoms as carotene are either hydrocarbons of definite configuration or alcohols or ketones of these same hydrocarbons. The hydrocarbons appear to fall into two groups, the carotenes, containing ionone rings and the lycopenes, aliphatic isomers of carotene. The existence of several isomeric carotenes has been established, but so far only one lycopene. The nomenclature now employed for the different carotenes, *i.e.*, α-, β-, etc., is fairly satisfactory both from a biological as well as a chemical standpoint. However, the nomenclature at present prevailing for the ketonic and alcoholic carotenoids is both unsatisfactory and also confusing.

According to the prevailing nomenclature for the alcoholic carotenoids it is necessary to choose between the following alternatives: (a) Retain the term xanthophyll as a term of historical value to designate the crystalline pigment mixture with the composition $C_{40}H_{56}O_2$, isolated by Willstätter[1] from green leaves; (b) employ the term xanthophyll in the future only in the plural, *i.e.*, xanthophylls, to designate the isomeric carotenoids having the composition $C_{40}H_{56}O_2$, analogous to the term carotenes for the isomeric carotenoids with the composition $C_{40}H_{56}$, and employ only specific names for various xanthophylls as isolated, as has already been done in the case of lutein and zeaxanthin, the two major and minor fractions so far isolated from the crystalline mixture from leaves, formerly called xanthophyll; new specific names could be given for any additional isomers which may be discovered in the future; (c) employ the old term xanthophyll for the major component of the crystalline mixture from green leaves, and give new names to the various isomers as isolated or discovered, as has been done in the case of the carotenoid zeaxanthin; this alternative would require the abandonment of the term lutein, the name given by Kuhn to the major xanthophyll-like pigment of green leaves.

In the main the first and second alternatives are favored by Kuhn[2] and the third alternative by Karrer.[3] The situation is analogous to that which developed when it became definitely known that vitamin B is composed of more than one component. In view of the fact that the discovery of isomeric forms of carotene was followed by the adoption of the more logical scheme of designating them as α- β- γ- and δ-carotene, respectively, instead of giving them specific names, and furthermore in view of the fact that xanthophyll (lutein) appears to be structurally related to α-carotene and zeaxanthin to β-carotene (as pointed out by Karrer[4]), another, more logical alternative of the present systems of xanthophyll nomenclature would be as follows: Employ the term xanthophyll as a generic term for the $C_{40}H_{56}O_2$ carotenoids, analogous to the generic term carotene and designate the specific xanthophylls as α-, β-, etc., to indicate their structural relationship to the corresponding α-, β-, etc., carotenes as their structure is elucidated. The "lutein" of Kuhn and the "xantho-

[4] Harvey Cushing, *Harvey Lectures*, 28: 90, 1932–33.

[1] R. Willstätter and W. Mieg, *Liebigs Ann.*, 355: 1, 1907.

[2] R. Kuhn, A. Winterstein and E. Lederer, *Z. f. physiol. Chem.*, 197: 141, 1931.

[3] P. Karrer, H. Wehrli and A. Helfenstein, *Helv. chim. Acta*, 13: 268, 1930.

[4] P. Karrer and H. Wehrli, *Nova Acta Leopoldina*, n. s., 1: 175, 1933.

phyll" of Karrer thus would become α-xanthophyll, and "zeaxanthin" would become β-xanthophyll. The likelihood of other xanthophylls occurring in nature is indeed rendered very probable by the discovery of γ-[5] and δ-carotene.[6]

Rhodoxanthin, for a number of years classified with the xanthophylls and whose empirical formula $C_{40}H_{50}O_2$ seems at first sight to justify such a classification, is now shown to be a ketonic carotene.[7] Therefore it can not be classed properly with the xanthophylls but must be grouped with the carotenes, not, however, as carotene with a new Greek letter prefix but as di-keto-β-carotene, which it appears to be.

Of course, there can be no serious objection raised to the use of specific names for the various esterified forms of the xanthophylls, such as "helenien" and "physalien," but if the nomenclature suggested above is used it would seem much better from a biochemical standpoint to designate them α-xanthophyll-dipalmitate (helenien) and β-xanthophyll-dipalmitate (physalien), respectively, since such names clearly indicate their chemical nature as well as their carotenoid affiliations.

The writer appreciates fully that the terms carotene and xanthophyll are not strictly chemical terms but originated from botanical taxonomic terms. In fact, the names which have been given to almost all the known polyene pigments have had a taxonomic origin either in botany or zoology. For this reason the name "lutein" is out of place in a system of nomenclature for pigments of plant origin. Nevertheless, a chemical influence has already been felt in connection with the spelling of the name carotene, which was formerly most frequently spelled "carotin," the name suggested by Wachenroder (1826). Arnand (1886) suggested "carotene" in keeping with the hydrocarbon structure, and the recent establishment of the polyene structure fully justifies this spelling, provided it be accepted that chemical structure should influence nomenclature and spelling of terms of botanical and zoological taxonomic origin. If this be accepted, then the logical spelling of the term xanthophyll should be xanthophyol or xanthophyllol to indicate the alcohol nature and provide for suitable euphony.

The idea of employing Greek letter designations for the different xanthophylls is not new but was proposed by both Tschirch[8] and Tswett[9] although each on different grounds and thus without any correspondence between the individual components of their respective systems. It is most interesting, however, to note that Tswett's xanthophyll-α turns out to be the pigment now known as "xanthophyll" or "lutein" which, as already mentioned, is related structurally to α-carotene and therefore should be called α-xanthophyll or α-xanthophyol (xanthophyllol). In fact, the writer some time ago[10] expressed the belief that the crystalline "lutein" of Willstätter and Escher[11] from egg yolk is the pure xanthophyll-α of Tswett, and this belief has been shown by Kuhn[12] to be about 70 per cent. correct.

A still more logical system of nomenclature for the alcoholic xanthophyll-like carotenoids would be one which could include all those structurally related to the isomeric carotenes, including those with three and four OH groups as well as the xanthophylls. With this idea in view the author suggests that the name xanthophyll be dropped entirely and that the generic name xanthin be adopted, which, as a matter of fact, is now used as a terminal ending for the names of all the C_{40} oxygen-containing carotenoids except xanthophyll (lutein) itself and the esters "physalien" and "helenien." In order to indicate the number of alcohol groups present the specific xanthins of this system would be given the terminal endings -ol, -diol, -triol, -tetrol, etc., and the structural relationships to the corresponding carotene would be indicated by the proper Greek letter, as soon as this relationship is established. Only in the case of special products such as the "cryptoxanthin" of Kuhn,[13] which possesses the β-carotene structure for one carbon ring and the zeaxanthin structure for the other, would a new compound name be necessary. It could be called β-carotene-β-xanthinol. If other such compounds are discovered, as they are likely to be, they could be named according to the structural relations of the carotene and xanthin portions of the molecule. For example, there could be conceivably an α-carotene-β-xanthinol, a β-carotene-γ-xanthinol, etc. Esters would be indicated by naming the acid involved after the xanthinol.

As indicated in a previous paragraph rhodoxanthin would not be generically one of these new xanthins, inasmuch as it is not an alcohol, but should be called di-keto-β-carotene. Although only one lycopene is known at the present time, its structural relation to the optically inactive β-carotene should be designated by the same prefix, *i.e.*, β-lycopene.

As regards the carotenoids with less than 40 C atoms, capsanthin, the paprika pigment, astacin, the red crustacean pigment and azafrin, the pigment of "azafran," can undoubtedly be made to fit into the proposed scheme as soon as their structure is known,

[5] R. Kuhn and H. Brockmann, *Ber.*, 66B: 437, 1933.
[6] A. Winterstein, *Z. f. physiol. Chem.*, 219: 249, 1933.
[7] R. Kuhn and H. Brockmann, *Ber.*, 66B: 828, 1933.
[8] A. Tschirch, *Ber. botan. Ges.*, 5: 128, 1887.
[9] M. Tswett, *Ber. botan. Ges.*, 29: 630, 1911.
[10] L. S. Palmer, "Carotinoids and Related Pigments." Chemical Catalog Co., New York, 1922.
[11] R. Willstätter and H. H. Escher, *Z. physiol. Chem.*, 76: 214, 1912.
[12] R. Kuhn and A. Smakula, *Z. physiol. Chem.*, 197: 161, 1931.
[13] R. Kuhn and Ch. Grundmann, *Ber.*, 66B: 1746, 1933.

for they apparently contain at least one ionone ring as well as an aliphatic conjugated polyene chain. Bixin and the safran pigments (crocetin and crocin) should probably be dropped from the true carotenoid classification, since it seems doubtful whether structural relationships to carotene will ever be established for them. As a matter of fact their polyene chain is all they have in common with the true carotenoids so far as chemical structure is concerned. Perhaps the designation pseudo- or secondary carotenoids would be better for them and their chemical classification based on the adoption of a generic name to indicate a common relationship, if that should prove possible, and a suitable terminology to show that they are carboxy acids.

The scheme proposed above is admitted to be a compromise with established practise of designating the oxygen-containing carotenoids by a distinct group name. However, attention may be called to the fact that it now seems entirely feasible to have a strictly chemical nomenclature for all the true carotenoids, based entirely on the terms carotene and lycopene or a combination of these terms. In this nomenclature the specificity of the true carotenes would be retained by use of the Greek letter prefixes which have already been assigned to them, except that "α" would specifically indicate the presence of optically active carbon atoms in the left- or right-hand ionone rings (or their open chain forms as they occur in lycopene), "β" will specifically represent the occurrence of only optically inactive carbons in the rings (or open forms of the rings). The order of naming the "α" and "β" rings (closed or open) would be from left to right. All the alcohol or ketone or combined alcohol-ketone (such as taraxanthin and fucoxanthin may be) derivatives of the carotenes would be given such designations as would indicate their respective relationships to the carotenes, and, in addition, the terminal endings -ol, -diol, -triol, -tetrol, etc., depending on the number of -OH groups; furthermore, such carotenes as possess the ketone structure would be indicated by the proper prefix, *i.e.*, keto-, diketo-, etc. The position of the various -OH and (or) $>C:O$ groups may also be indicated according to the usual organic chemistry nomenclature, as soon as this is determined.

The accompanying table shows the schemes for both the suggested new generic nomenclature for the C_{40} oxygen-containing carotenoids, and also for the proposed new strictly chemical nomenclature so far as the structural relationships to the carotenes are known.

CAROTENOID NOMENCLATURE

Old name	Formula	Proposed new generic name	Proposed new chemical name
α-carotene	$C_{40}H_{56}$	α-carotene	βα-carotene
β-carotene		β-carotene	ββ-carotene
γ-carotene		γ-carotene	β-lyco-β-carotene
δ-carotene, etc.		δ-carotene, etc.	β-lyco-α-carotene, etc.
Lycopene	$C_{40}H_{56}$	β-lycopene	ββ-lycopene
Rhodoxanthin	$C_{40}H_{50}O_2$	diketo-β-carotene	5, 5′-diketo ββ-carotene
Xanthophyll / Lutein	$C_{40}H_{54}(OH)_2$	α-xanthin-diol	βα-carotene-5, 5′-diol
Zeaxanthin	$C_{40}H_{54}(OH)_2$	β-xanthin-diol	ββ-carotene-5, 5′-diol
Flavoxanthin	$C_{40}H_{52}(OH)_3$	α-xanthin-triol	βα-carotene-(?)-triol
Taraxanthin	$C_{40}H_{52}O(OH)_3$	α-keto-xanthin-triol	(?)-keto-βα-carotene(?)-triol
Violaxanthin	$C_{40}H_{52}O(OH)_3$	β-keto-xanthin-triol	(?)-keto-ββ-carotene-(?)-triol
Fucoxanthin	$C_{40}H_{52}O_2(OH)_4$	(?)-diketo-xanthin-tetrol	(?)-diketo-(?)-carotene-(?)-tetrol
Cryptoxanthin	$C_{40}H_{55}OH$	β-carotene-β-xanthinol	β5′β-carotenol
Helenien	$C_{72}H_{116}O_2$	α-xanthin-diol-dipalmitate	βα-carotene-5, 5′-diol-dipalmitate
Physalien	$C_{72}H_{116}O_2$	β-xanthin-diol-dipalmitate	ββ-carotene-5, 5′-diol-dipalmitate
Capsanthin	$C_{35}H_{50}O_3$	?	?
Azafrin	$C_{27}H_{38}O_4$	hemi-α-xanthin-diol	di-α-1, 2-carotene-diol-(?)
Astacin	$C_{27}H_{32}O_3$	?	?

NOTE: The question mark indicates either (a) lack of information regarding the position of the known ketonic or hydroxyl group or (b) the group suggested has not been proved or (c) the structure is partly or wholly unknown.

The writer hopes that these suggestions will prompt discussion which will lead to the adoption of some logical biochemical nomenclature and prevent the accumulation of more confusion of names for these interesting and important substances while their chemistry is new and before long-established usage makes such adoption difficult if not impossible to secure.

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BOOKS RECEIVED

MARTIN, ERNEST G. and H. NEWELL MARTIN. *The Human Body.* 12th Edition. Pp. xv + 701. 167 figures. Holt. $4.00.

SWINGLE, DEANE B. *A Textbook of Systematic Botany.* Second Edition. Pp. xv + 270. McGraw-Hill. $2.25.